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ABSTRACT

The National Aeronautics and Space Administration (NASA) has produced a distance learning series of four 60-minute video programs with an accompanying Web site and companion teacher guide. This teacher guide accompanies the third video in the series. The story line of each program involves six ethnically diverse, inquisitive schoolchildren who meet in a treehouse. They seek the solution to a particular problem, and the NASA "Why?" Files series follows them through the steps of their investigation and final conclusion. In this program, many neighborhoods lose electrical power during a severe storm. After the storm, the treehouse detectives notice that the houses across the street from them remain without power, even though power was quickly restored to all other residences. In this part of the series, students learn about static electricity, sources of power for electricity, and components of a circuit. The teacher guide includes a program overview as well as geography, science, mathematics, and educational technology concepts as related to the National Standards. Each 15-minute program segment is described along with objectives, key vocabulary, suggestions for the most effective use of the videos and Web site in the classroom, and resources. In addition, each segment is accompanied by activities and worksheets. (PVD)

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The NASA "Why?" Files
The Case of the Electrical Mystery

Program 3 in the 2000-2001 Series

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The NASA "Why?" Files
whyfiles.larc.nasa.gov

Educator's Guide	
Teachers & Students	Grades 3-5

EP-2000-09-20-LaRC

Educator's Guide	
Teachers & Students	Grades 3-5

EP-2000-09-20-LaRC

For additional information about the NASA "Why?" Files, contact Shannon Ricles at (757) 864-5044 or e-mail at **s.s.ricles@larc.nasa.gov**

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The American Institute of Aeronautics and Astronautics (AIAA) provides classroom mentors to educators who register for the NASA "Why?" Files. Every effort will be made to match a teacher with an AIAA member who will mentor the teacher either in person or by e-mail. To request a mentor, e-mail nasawhyfiles@aiaa.org

AIAA FOUNDATION

*Contact the AIAA to get a classroom mentor at **nasawhyfiles@aiaa.org**.*

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Index

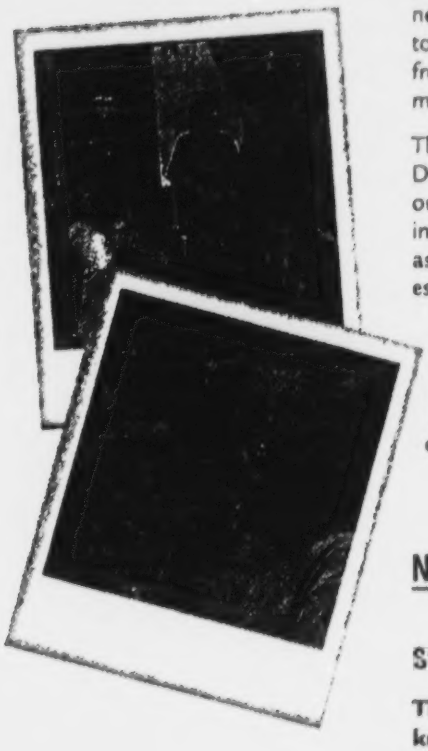
Program Overview 4
National Geography Standards 4
National Math Standards 5
National Science Standards 6
National Educational Technology Standards .7

Part 1 **Segment 1**
Segment Overview 9
Objectives 10
Vocabulary 10
Video Component 11
Careers 12
Resources 12
Activities and Worksheets 13

Part 2 **Segment 2**
Segment Overview 21
Objectives 22
Vocabulary 22
Video Component 23
Careers 23
Resources 23
Activities and Worksheets 25

Part 3 **Segment 3**
Segment Overview 35
Objectives 36
Vocabulary 36
Video Component 36
Careers 37
Resources 37
Activities and Worksheets 38

Part 4 **Segment 4**
Segment Overview 49
Vocabulary 50
Video Component 50
Careers 51
Resources 51
Activities and Worksheets 52



Program Overview

The tree house detective are eager to go swimming in Mr. E's pool, but a severe storm moves through the area of Wattsville. During the storm many neighborhoods lose electrical power. Once the storm ends, power is restored to most residents, but the tree house detectives notice that the houses across from the tree house are still without power, including Mr. E's house. This mystery becomes their "current" case to solve: *The Case of the Electrical Mystery.*

The tree house detectives are "charged" about this new case, and they visit Dr. D to get advice on how to solve the mystery. Dr. D directs them to various NASA researchers and offers "mini" science lessons throughout their investigation. The tree house detectives use their scientific inquiry skills, and as they gain knowledge about electricity, they periodically revise their hypothesis. With reports from I. M. Listening, KSNN (Kids Science News Network) reporter, they begin to unravel the solution to the case.

Tune in to see what is causing the houses across the street to be without power and to find out if the tree house detectives ever get to go swimming. Use your scientific investigation skills to cut through the "static" to discover the ending to the mystery.

National Geography Standards (grades 3-5)

Standard	Segment 1	2	3	4
The geographically informed person knows and understands:				
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire, process, and report information from a spatial perspective				
Environment and Society				
How human actions modify the physical environment				
The changes that occur in the meaning, use, distribution, and importance of resources				
The Uses of Geography				
How to apply geography to interpret the present and plan for the future				

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National Math Standards (grades 3–5)

Standard	Segment 1	2	3	4
Numbers and Operations				
Understand numbers, ways of representing numbers, relationships among numbers, and number systems				✖
Algebra				
Represent and analyze mathematical situations and structures using algebraic symbols				✖
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement		✖	✖	✖
Apply appropriate techniques, tools, and formulas to determine measurements				✖
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them				✖
Select and use appropriate statistical methods to analyze data				✖
Problem Solving				
Solve problems that arise in mathematics and in other contexts				✖
Apply and adapt a variety of appropriate strategies to solve problems	✖		✖	✖
Communication				
Analyze and evaluate the mathematical thinking and strategies of others				✖
Connections				
Recognize and apply mathematics in contexts outside of mathematics	✖	✖	✖	✖
Representation				
Create and use representations to organize, record, and communicate mathematical ideas	✖	✖		✖
Use representations to model and interpret physical, social, and mathematical phenomena	✖	✖	✖	✖

National Science Standards (grades k-4)

Standard	Segment 1	2	3	4
Unifying Concepts and Processes				
Systems, orders, and organization			✖	
Evidence, models, and explanations	✖		✖	
Change, constancy, and measurement	✖			
Science and Inquiry (A)				
Abilities necessary to do scientific inquiry	✖		✖	
Understanding about scientific inquiry	✖		✖	
Physical Science (B)				
Properties of objects and materials	✖		✖	
Light, heat, electricity, and magnetism	✖		✖	
Earth and Space Science (D)				
Properties of earth materials	✖			
Science and Technology (E)				
Abilities of technological design	✖		✖	
Understanding about science and technology	✖		✖	
Science in Personal and Social Perspective (F)				
Types of resources				
Science and technology in local challenges	✖		✖	
History and Nature of Science (G)				
Science as a human endeavor	✖	✖	✖	

National Science Standards (grades 5-8)

Standard	Segment 1	2	3	4
Unifying Concepts and Processes				
Systems, order, and organization			✖	
Evidence, models, and explanations	✖		✖	
Change, constancy, and measurement	✖			
Science as Inquiry (A)				
Abilities necessary to do scientific inquiry	✖		✖	
Understandings about scientific inquiry	✖		✖	
Physical Science (B)				
Properties and changes of properties in matter	✖			
Transfer of energy	✖		✖	
Earth and Space Science (D)				
Structure of the earth system	✖			
Science and Technology (E)				
Abilities of technological design	✖		✖	
Understanding about science and technology	✖		✖	
Science in Personal and Social Perspectives (F)				
Populations, resources, and environments				
Natural hazards	✖			
Risks and benefits				
Science and technology in society	✖	✖	✖	
History and Nature of Science (G)				
Science as a human endeavor	✖		✖	
Nature of science	✖		✖	
History of Science			✖	

National Educational Technology Standards (grades 3–5)

Performance Indicators for Technology-Literate Students

Standard	Segment 1	2	3	4
Basic Operations and Concepts				
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	x		x	x
Social, Ethical, and Human Issues				
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	x		x	
Discuss basic issues related to responsible use of technology and information and describe personal consequences of inappropriate use.	x			x
Technology Productivity Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	x		x	
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	x		x	
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.			x	
Use telecommunication and on-line resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.			x	
Technology Research Tools				
Use telecommunication and on-line resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.		x	x	
Use technology resources for problem solving, self-directed learning, and extended learning activities.		x	x	x
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.				x
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.		x	x	
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.		x		x

The NASA "Why?" Files
The Case of the Electrical Mystery

Segment 1

Once again the NASA "Why?" Files tree house detectives are involved in trying to solve a case. As a powerful thunderstorm approaches Big City, the tree house detectives decide that it would be best to cancel their plans to go swimming and leave the tree house to head for the safety of their homes. The storm knocks out power to many local residents, but it is quickly restored to all the residences except the houses located across from the tree house. The tree house detectives are puzzled by this occurrence, and they decide to make this their next case, *The Case of the Electrical Mystery*. With Dr. D's help, the tree house detectives learn about static electricity. Dr. D reviews how to conduct a scientific investigation and recommends they visit a NASA Langley researcher to gather information about lightning to help them solve the mystery.

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Objectives

Students will

- experiment with static electricity.
- learn that charged objects attract neutral and other charged objects.
- learn that objects have a negative, positive, or neutral charge.
- discover that opposite charges attract and like charges repel.
- learn that an atom has a proton, an electron, and a neutron.
- learn that protons are positively charged and that electrons are negatively charged.
- discover that the fast movement of electrons through the air causes the air to heat and then to glow.
- learn how cloud-to-ground and cloud-to-cloud lightning forms.
- learn how lightning research helps to create safer commercial, fighter, and shuttle flights.

Vocabulary

amber - crystallized fossil form of the sticky resin product produced by some trees. It is capable of gaining a negative charge by friction.

discharge - the release of stored energy

electrical charge - amount of electricity in or on an object

electricity - a form of energy produced by the flow or accumulation of electrons

electron - a subatomic particle with a negative electrical charge

lightning - visible bright flash created from the discharge of the current between areas of opposite charges and between clouds or cloud-to-ground

neutron - a subatomic particle with a neutral (no) electrical charge

power outage - a loss of electrical power

power source - point from which the power flows, such as a battery

proton - a subatomic particle with a positive electrical charge

repel - to drive or to force back

severe thunderstorm warning - severe weather conditions exist and immediate action should be taken

static electricity - the buildup of electrical charges on a surface produced by contact and separation of dissimilar materials. In this type of electricity, the electrical charge is on something, and it does not move through a circuit.

thunder - sound heard from the rapid heating and expansion of the air around a lightning bolt which forms a sound wave

turbulence - a disturbance in the atmosphere caused by uplift of winds

Van de Graff generator - a machine that is used to produce very high voltoages; invented by physicist Robert Jemison Van de Graff in 1930

Video Component (15 min)

Before Viewing the Video

Introduce the video to the students by having them discuss what happened when the storm knocked out power in their homes. What were the effects?

1. Create a K-W-L chart as a class, which includes "What do we **know**?" (K),"What do we **want** to find out?" (W), and "What have we **learned**?" (L) The first two columns should be completed now, with the third completed later. Subjects might include electricity use in our daily lives, how batteries work, how lightning is made, and/or how electricity flows through wire. Reinforce with the students the rules of brainstorming:

   Accept all ideas from others, even if you don't agree with them.
   Don't criticize other people's ideas.
   Listen to other people's good ideas.

What do we **know**?	What do we **want** to find out?	What have we **learned**?

2. From the NASA "Why?" Files web site (see p. 24), download a copy of the Problem Board for the students to use while viewing the video. Have the students complete the chart as the tree house detectives complete their problem board. You may wish to pause the video, as appropriate, for students to record the information.

3. As a class project, collect information from the news media and the Internet about static electricity, lightning, and current electricity. You might explain that static electricity is what shocks you when you walk in bedroom slippers across a carpet and touch the doorknob. Current electricity is what we use with flashlights or electric appliances.

3. Review important safety rules when investigating electricity.

   Keep fingers and objects away from electrical outlets.
   Never fly kites near power lines.
   Never climb trees near power lines .
   Keep ladders and TV antennas away from power lines.
   Never overload outlets with too many plugs.
   Never pull a plug out by the cord.
   Never use radios or hair dryers around bathtubs or showers.
   Stay away from downed power lines and electric company substations.
   Keep a boat's mast away from power lines.
   Never work on an appliance or take it apart while it is plugged into the socket.

4. Have the students try out the simple static electricity experiments from the guide and the NASA "Why?" Files web site, http://whyfiles.larc.nasa.gov

After Viewing the Video

Discuss the questions that are asked at the end of the first segment.

- What are some reasons that Dr. D's train set doesn't work?
- What caused the power outage to happen on one side of the street and not the other?
- Did the lightning storm cause the power outage?
- How should the tree house detectives use what they have learned to investigate more?

2. Make a display board of the processes used in conducting a scientific investigation. You may wish to go to the NASA "Why?" Files web site, **http://whyfiles.larc.nasa.gov** to review and print information on scientific investigation from the previous programs. Include the following words on the display board: problem statement, research, materials, hypothesis, procedure, data, conclusion, variables, information, experiments, and questions. Some of these words may be used several times during an investigation. (For example, the detectives change their hypothesis several times as they discover new information.) Have the students write down the steps that the tree house detectives use to solve the problem during the four video segments.

3. Research the types of precautions that should be taken during thunderstorms and have the students use the resources below to prepare informational posters about the safety rules.

4. Investigate more activities in this guide and on the web site.

Careers

nuclear physicist
aerospace engineer
electrical engineer
meteorologist
storm chaser
physical science teacher

Resources

Books

Parker, Steve: *Eyewitness Science: Electricity.* DK Publishing, Incorporated, 1992, ISBN 1879431823

Birch, Beverly with Robin Bell Corfield: *Benjamin Franklin's Adventures with Electricity.* Barron's Educational Series, Incorporated, 1996, ISBN 0812097904

Granowsky, Alvin, Craig, and Joy Tweedt: *Zak and Ben.* Modern Curriculum Press, 1985, ISBN 0813651611

Leon, George de Lucenay: *The Story of Electricity: With 20 Easy-to-Perform Experiments.* Dover Publications, 1991, ISBN 0486255816

Web Sites

What is Energy?
The site introduces students to what energy is and provides further information on ten sources of energy including electricity.
http://www.eia.doe.gov/kids/

The Atoms Family
The web site has many fun pages to explore! The featured web page incorporates facts about electrical safety in a "What's Wrong with this Picture" format. It also includes experiments that put your knowledge of static and electrical to the test.
http://www.miamisci.org/af/sln/frankenstein/

Energy Quest's "The Energy Story"
This student friendly site provides a clear overview of electricity and highlights a balloon experiment that applies the concepts reviewed in the story.
http://www.energy.ca.gov/education/story/story-html/chapter02.html

Theatre of Electricity
This site features the electricity generator known as the Van de Graaff.
http://www.mos.org/sln/toe/construction.html

Lightning: The Shocking Story
The National Geographic web site features the science of lightning, striking lightning photos, stories of survivors of lightning strikes, and a static electricity experiment.
http://www.nationalgeographic.com/lightning/

NASA "Why?" Files Web Site
Official web site of the NASA "Why?" Files. Student, teacher, and parent friendly.
http://whyfiles.larc.nasa.gov

ALFY - The Kids Portal Playground: Electricity and Magnetism
ALFY's Picks has a number of web sites that are fun and educational. Magnets, magnetic forces, conductors, static electricity, and electricity are some of the topics you can explore on this colorful and fun-filled site.
http://www.alfy.com/Teachers/Teach/Thematic_Units/Electricity_Magnetism/EM_1.asp

NASA Research and Missions
Lightning Detection from Space: A Lightning Primer
The Lightning Primer provides information about Lightning and the history of the scientific research conducted to learn more about this natural wonder. NASA's Marshall Space Flight Center has played an important role in the collection and interpretation of lightning data gathered from space and on the ground. Review this site to see how this data is making a difference in future scientific ventures and studies.
http://thunder.msfc.nasa.gov/primer/primer2.html

Activities and Worksheets

In the Guide

Dr. D's Lab Experiments 14
Fun and easy to perform experiments on static electricity.

Cling On 15
Students explore static electricity and learn how like and unlike charges respond.

Atoms & Atoms Everywhere 16
Students will learn the basic components of an atom.

Lightning – Folklore and Mythology ..17
Language arts activity that explores myths and legends.

Benjamin, Oh, Benjamin 18
Find out the real story of Benjamin Franklin as students research the facts of his life.

Staying Electrically Safe 19
Safety rules to follow when working and playing around electricity.

On the Web

You can find the following activities on the Web at http://whyfiles.larc.nasa.gov.

Static Glow
Activity that lights a fluorescent bulb to demonstrate static electricity flow.

Parts of an Atom
A student assessment activity on the parts of an atom.

Dr. D's Lab Experiments

Try some of the experiments that Dr. D did in his lab.

Experiment 1 Tear a piece of paper into tiny pieces. Stroke a comb through your hair several times. Place the comb near the paper pieces.

What happened? _____

Why? _____

Experiment 2 Blow up a balloon and rub the balloon on your head. Place the balloon near the paper pieces and observe what happens. Repeat with salt or puffed rice.

Why are the paper and other objects attracted to the balloon? _____

_____

Do the objects stay attracted to the balloon? _____

Why or why not? _____

Rub the balloon on your head and try sticking the balloon to the wall.

Why does it stick? _____

Time how long the balloon stays up on the wall.

Why does the balloon eventually fall? _____

_____

What would make the balloon stay up longer? _____

_____

Rub the balloon on your head and hold the balloon near a small stream of water coming from your faucet.

What happened? _____

_____

Why? _____

Explanation Static electricity exists whenever there are unequal amounts of positively and negatively charged particles present. Rubbing the balloon or comb on your hair makes the balloon or comb have more of one type of charge. The rubbing transfers the electrons from you to the balloon surface and gives the balloon a negative charge. As you bring the balloon near the objects, the balloon induces a positive charge on the objects and opposite charges attract. When the objects and the balloon touch, electrons flow from the balloon to the objects, giving the objects a negative charge. Now that the balloon and the objects both have the same charge, they repel each other; hence, they fall off the balloon.

Misconceptions Static electricity is not caused by friction. It appears when two unlike materials make contact and then are separated. All that is required is the actual touching of the two materials. Rubbing will increase the total contact area between the materials and this will, in turn, make the materials more electrically dissimilar. Rubbing enhances static electricity, but it is not the cause.

Cling On

Purpose

To provide students with the opportunity to discover static cling and to observe how some objects attract and some repel.

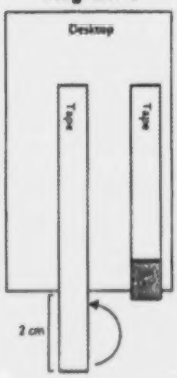
Materials

transparent tape in dispenser
science journal
notebook

Procedure

1. Working with a partner, tear two strips of tape, each about 10 cm long from the tape dispenser.
2. Stick them to your desktop, leaving about 2 cm hanging over the edge.
3. Fold the edge back so that there's a nonstick part to hold onto. See diagram 1.
4. Hold onto the nonstick parts and slowly peel the strips off the desk, so that the tape doesn't curl.
5. Hold the two strips by their ends and bring them close together (nonstick sides). What happens? Record your observations in your science journal.
6. Now, have your partner gently rub a finger over both strips several times.
7. Bring the strips together again. What happened? Record your observations in your science journal.
8. Stick one of the strips back on your desk and stick the other one right on top of it.
9. Peel both strips off your desk and then gently peel both strips apart. Predict what will happen when you bring the two strips together. Have your partner record your prediction in your science journal.
10. Test your prediction and record your observations in your science journal.
11. Have your partner rub the strips several times again and predict what will happen when you bring the strips together after they have been stroked.
12. Test your prediction and record your observations in your science journal.

Diagram 1



Conclusion

What happened when you brought the strips of tape near each other the first time?____

_____

The second time?_____

_____

Why?_____

What happened after the tape was rubbed by your partner's finger?_____

_____

Why?_____

What other things have you seen that behave as the tape does?_____

_____

How were these other things like the tape?_____

How were they different?_____

Extension

1. Place some plastic drinking straws on a table. Charge a plastic pen with static by rubbing it with a wool cloth. Place the pen close to the straws.

   What happens?_____

   Why?_____

2. Try a variety of hairbrushes and combs made out of different materials like plastic, wood, or metal.

   Does your hair behave differently with each?_____

   Which one would give you a "bad" hair day?_____

3. Brainstorm for ideas about how static electricity is produced in nature.

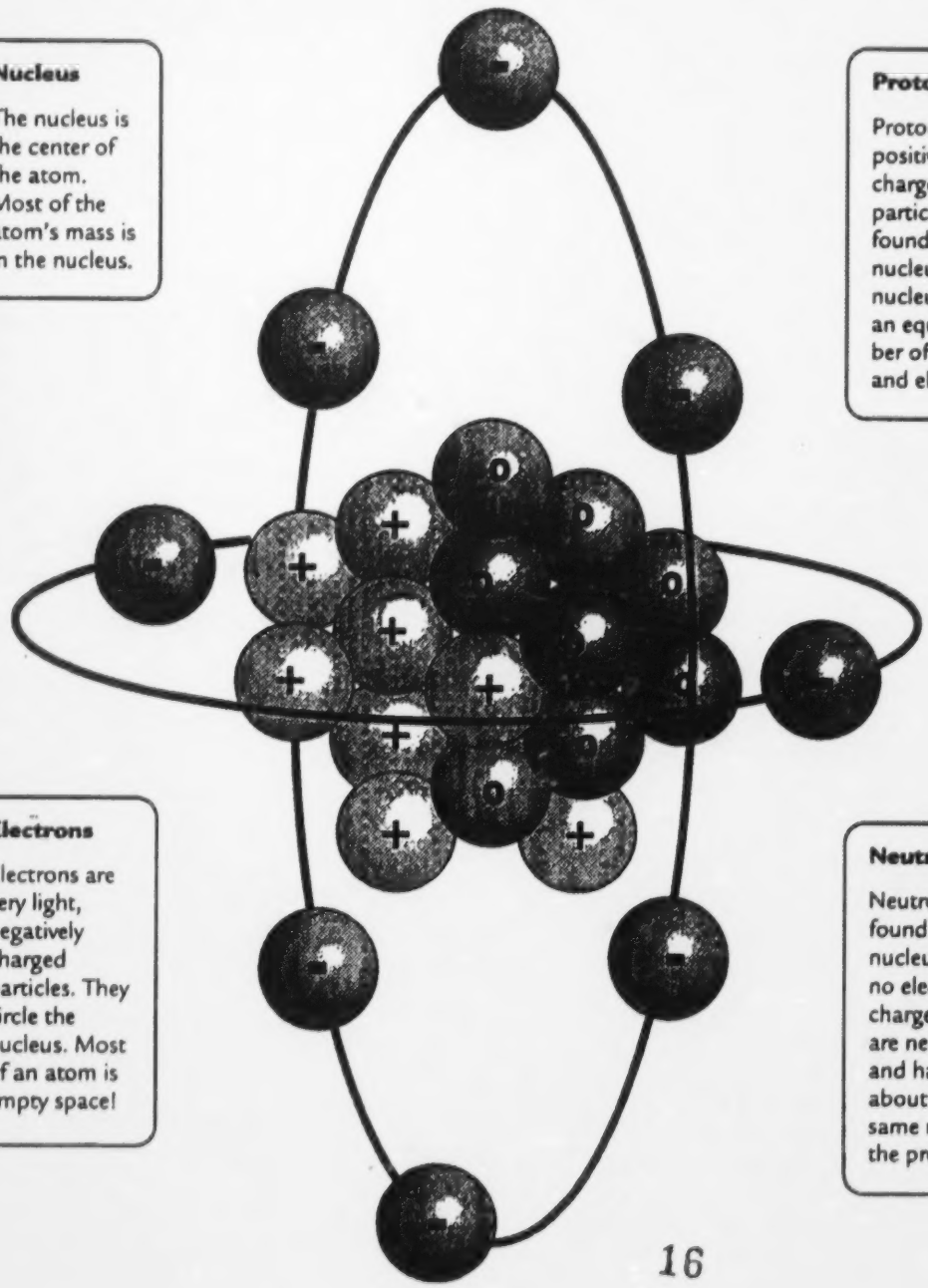
   Does weather make a difference?_____

Atoms & Atoms Everywhere

Read the clues and draw a line from the clue to the part of the atom that it describes.

Nucleus

The nucleus is the center of the atom. Most of the atom's mass is in the nucleus.



Protons

Protons are positively charged of particles found in the nucleus. The nucleus has an equal number of protons and electrons.

Electrons

Electrons are very light, negatively charged particles. They circle the nucleus. Most of an atom is empty space!

Neutrons

Neutrons, also found in the nucleus, have no electrical charge. They are neutral and have about the same mass as the proton.

16

Lightning – Folklore and Mythology

Many cultures have passed down stories about lightning over the centuries. The Greeks, Romans, and Norsemen all told stories of gods who ruled with lightning rods. Zeus was the king of the Greek gods who ruled from Mount Olympus. Zeus is the equivalent to the Roman god Jupiter, who protected the universe and Rome with his lightning bolt. Thor, a fierce warrior, was the Norse god who rode through the heavens during thunderstorms in his goat-pulled chariot. When Thor threw his hammer, lightning flashed throughout the skies.

1. Choose one of these three mythological gods or another of your own choosing and research the myth which surrounds him. You may use the Internet, books, encyclopedias, or other sources to conduct your research. Write a report on the mythical god that you chose and be sure to include several interesting facts!

2. Once you have researched your mythical god, create a story that depicts a day in his life. Be sure to include how he used lightning to control his world. Illustrate your story.

3. Investigate other cultures to determine whether they had mythical gods known for using lightning. Investigate folklore to see how other cultures explained lightning.

Benjamin, Oh, Benjamin

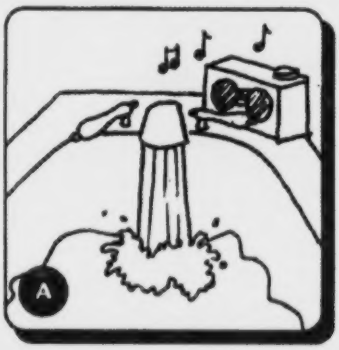
Was Benjamin Franklin's kite really struck by lightning? Why did Benjamin Franklin want to fly a kite in a storm? What did it prove? Was he the first one to perform this experiment? Was he doing research?

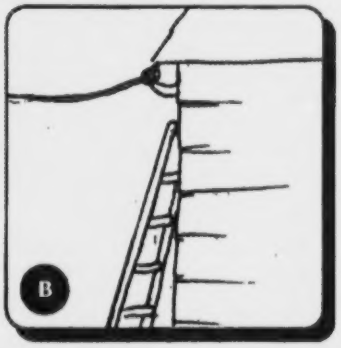
Investigate the true story of Benjamin Franklin and his flying electrifying kite experiment. Write a story for your local newspaper giving the who, what, where, when, and why of Benjamin Franklin and his famous experiment.

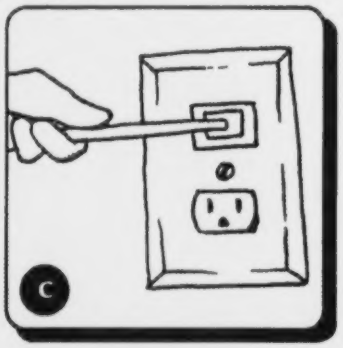
EXTRA! EXTRA! READ ALL ABOUT IT!

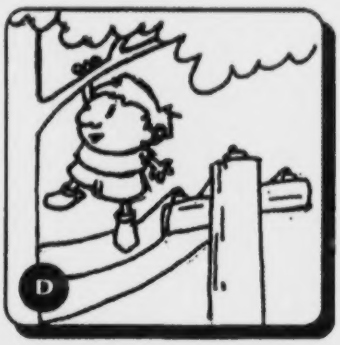
CAPTION: _____

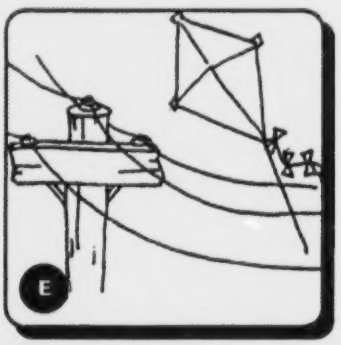
Staying Electrically Safe

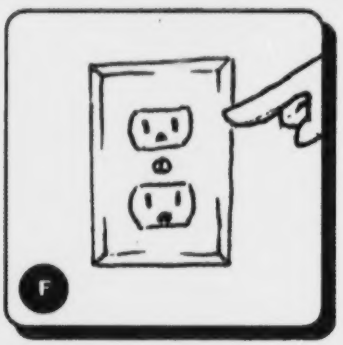


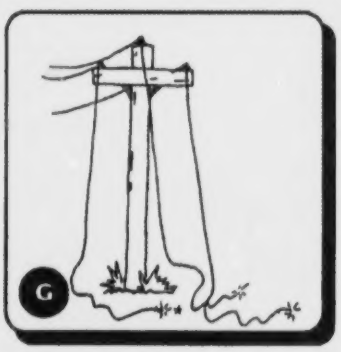


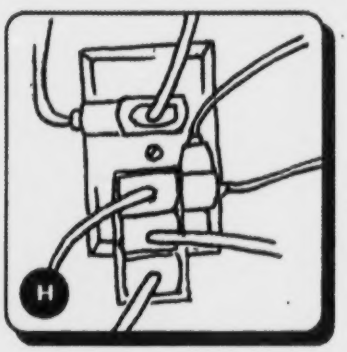


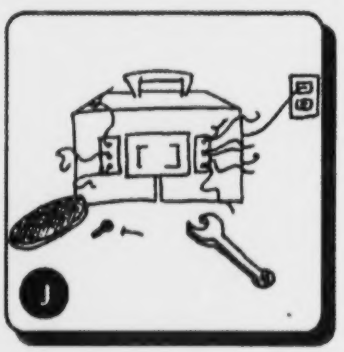






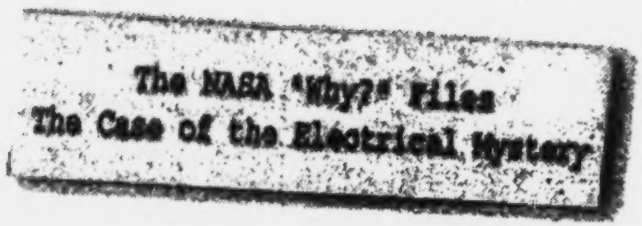






Match the safety rule to the appropriate picture.

_____1. Keep fingers and objects away from electrical outlets.
_____2. Never fly kites near power lines.
_____3. Never climb trees near power lines.
_____4. Keep ladders and TV antennas away from power lines.
_____5. Never overload electrical outlets with too many plugs.
_____6. Never pull a plug out by the cord.
_____7. Never use radios or hair dryers around bathtubs or showers.
_____8. Stay away from downed power lines and electric company substations.
_____9. Never work on an appliance or take it apart while it is plugged into the socket.



Segment 2

As the tree house detectives continue trying to solve the case, they learn that electricity is a form of energy. They also learn that in a standard circuit, electricity comes from the flow of electrons. There are several ways to force the charges to flow. Some sources that provide energy to generate electricity are these: chemical, hydro, solar, mechanical, wind, water, nuclear fission, and the burning of natural gas, coal, and oil. The tree house detectives are intrigued and want to learn more about hydroelectric power. They send an e-mail to a power plant in Niagara Falls; through a teleconference, they learn how a hydroelectric power plant creates and distributes electricity. At the same time, KSNN issues a report that electrical power has been restored to most customers; however, the power continues to be out across the street. The detectives are baffled. They decide that they must do more research!

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Objectives

Students will

- learn about various sources of power for the production of electricity such as chemical, hydro, solar, mechanical, wind, water, natural gas, coal, oil, and nuclear fission.
- learn the components of a hydroelectric power plant.
- understand how power is produced at a hydroelectric power plant.
- learn how the United States and Canada cooperate to share the Niagara River as a resource while preserving the beauty of Niagara Falls.
- compute the amount of water that flows over Niagara Falls during tourist season.
- learn possible causes for power outages.

Vocabulary

anemometer - an instrument for measuring and indicating the force of speed of the wind

battery - two or more dry cells that are connected and use chemicals to generate and store a direct current of electricity

chemical energy - a form of energy in which chemical compounds interact to create electricity

circuit - unbroken path of an electrical conductor that allows electrical current to flow from the power source and back again

current - moving electrical charges

electric eel - a long fish with organs capable of producing a powerful electric discharge

energy - the ability to make something happen or do work

forebay - a canal that water flows into from a river and where the water is held until it is used by a hydroelectric power plant to produce electricity

generator - a device that uses a moving magnetic field and a coiled conductor to produce alternating electric current

hydroelectric - using water to produce electricity

kilowatt - a unit used to measure large amounts of electricity —1,000 watts

mechanical energy - energy associated with motion

nuclear fission - splitting of an atom's nucleus into two smaller parts of approximate equal mass, during which nuclear energy is released

overload - to load too heavily; an excessive load

reservoir - a place where water is collected and stored for use

solar cell - a type of generator that produces electricity whenever sunlight shines on it

solar energy - energy given off by the Sun

treaty - an agreement between two groups, such as two nations

turbines - a paddle wheel in an engine that rotates by the introduction of steam, water, or wind and which, in turn, produces mechanical energy

variable - a factor that is being tested in an experiment

wind energy - energy that is created by wind

Video Component (15 min)

Before Viewing

1. Briefly summarize and discuss the events in segment 1 with the students.
2. Review the K-W-L chart (p. 11) that the class created earlier. Add items in the third column, "What have we **learned**?" Identify things to add to the "What do we **want** to find out" list?
3. Ask the students to predict why the power went out and what they think the tree house detectives will investigate next.

After Viewing

1. Discuss the questions asked in Segment 2 at the end of the video.
   - How will learning about the power plant help the tree house detectives solve their case?
   - Are they right to revise their hypothesis?
   - What do you think is wrong with Dr. D's train?
2. In small groups, have the students research how electricity is generated in their area. Contact your local utility company for information or perform a web search for other utility companies in your state/region. Many have extensive education/public outreach programs offering printed information and speakers that will visit your classroom.
3. Review the vocabulary used in the segment and ask the students to use the words to write and illustrate the definitions in their own words.
4. Choose from the activities in this packet and on the web site to reinforce the concepts being emphasized.
5. Continue working with the K-W-L chart to reinforce the investigative steps the tree house detectives are taking to solve the problem. Point out that the detectives frequently stop to summarize what they know and discuss what they need to know. They also revise their hypothesis if necessary.
6. As a class, hypothesize possible causes of the break in electricity between the power source and the houses across the street.

Careers

electrical engineer
hydroelectric power plant manager
conservationist
wind farm manager
chemist
physicist

Resources

Baker, Wendy, Alexander Parsons, and Andrew Haslam: Electricity. World Book, Incorporated, 1998, ISBN 0716647036

Chapman, Philip and Phil Chapman: *Electricity (The Usborne Young Scientist Series)*. EDCP Publications, 1990, ISBN 0860200787

Cole, Joanne and Bruce Degen: *The Magic School Bus and the Electric Field Trip.* Scholastic, Inc., 1998, ISBN 0590446835

Bartholomew, Alan: Electric gadgets and Gizmos: *Battery-Powered Buildable Gadgets That Go!* General Distribution Services, 1998, ISBN 1550744399

Web Sites

Energy Ed Education Event's "Electric Motor"
This site features the creation of an electric motor and explains how it works.
http://www.energyed.ergon.com.au/activiti/4/experime.htm

Howard R. Swearer Center for Public Service
The public service outreach program provides lessons on various topics. The Circuits Lesson is featured.
http://www.brown.edu/Departments/Swearer_Center/Projects/PSO/Circuits.shtml

An Inside Look at Electricity
Web66: A K12 World Wide Web Project designed this site to help introduce technology into the classroom. Students did this project and published their findings on the web for those who are interested in learning more about electricity and Ben Franklin.
http://web66.coled.umn.edu/hillside/franklin/jummy/Project.html

Wind Farms of the World
Take a tour of selected wind farms around the world. The wind power plants in the tour are located in California, India, the United Kingdom and Continental Europe.
http://rotor.fb12.tu-berlin.de/windfarm.html

NASA "Why?" Files Web Site
Official web site of the NASA "Why?" Files. Student, teacher, and parent friendly.
http://whyfiles.larc.nasa.gov

Activities and Worksheets

In the Guide

Fruity Energy 26
Student will build and test various fruits for the amount of energy they produce.

Battery Tester 27
Students will build a battery tester to test for the flow of electric current.

Solar Cell Simulation 28
Simulation of sunlight striking a solar cell.

Hydroelectic Power 29
Students will learn how hydroelectric plants create energy.

Water Turbine 30
Construct a simple water turbine to demonstrate how to create energy with the flow of water.

Fun with Wind 31
Create your own anemometer and discover solar power.

Sun Cooking with a Chance of Rain ... 32
Build a solar cooker to learn the effect of color on heat absorption.

Answer Key 33

On the Web

You can find the following activities on the Web at http://whyfiles.larc.nasa.gov.

To There and Back
Calculate the distance to Niagara Falls from your hometown.

Solar Cooker
Build a solar cooker and make lunch!

Fruity Energy

Purpose

Students will build a battery from fruit, test various fruits for conductivity, and compare the amount of energy they each produce.

SAFETY If no copper electrode is used, hydrogen gas is given off as a byproduct of the reactions taking place; therefore, be careful not to perform this experiment near heat sources or open flames.

Materials (per group)

- several varieties of fruit (lemon, orange, apple, pear, kiwi, and grape)
- one 3-cm X 0.5-cm piece of zinc metal (zinc electrode)
- one 3-cm X 0.5-cm piece of copper metal (copper electrode)
- two 30-cm pieces of insulated copper wire
- small lamp such as a penlight or flashlight bulb (LED displays work great)
- lamp holder
- 2 paper clips
- wire strippers

Procedure

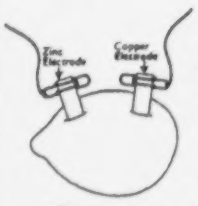

Diagram 1

1. Stick zinc electrode into fruit.
2. Place the copper electrode on the opposite side of the zinc electrode.
3. Place a paper clip on each of the electrodes. See diagram 1.
4. Strip about 2 cm of insulation from each piece of wire on both ends.
5. Attach one end of a wire to the paper clip on the zinc electrode.
6. Attach one end of the other wire to the paper clip on the copper electrode.
7. Insert bulb into the bulb holder.
8. Wrap the other ends of each copper wire around the posts of the bulb holder.
9. Observe the brightness of the bulb and record observations in science journal or in data chart.
10. Repeat with other fruits and compare the brightness of the bulbs.

NOTE One way to compare brightness more accurately than by a subjective opinion is to place a sheet of paper in front of the bulb and keep adding paper until the light can no longer be seen. Then compare how many sheets of paper it took for each fruit.

11. In your science journal create a chart like the one on the right.

Type of Fruit	Brightness/Number of Papers	Comments or Other Observations
Lemon		
Orange		
Apple		
Pear		
Kiwi		
Grape		

Conclusion

1. Define the term acidic.
2. Can fruits be acidic?
3. What do the fruits that lit the bulb have in common?
4. Why did only some of the fruits light the bulb?
5. How did the brightness of the bulb differ among fruits? Why?
6. What other fruits or vegetables would light a bulb?

Extensions

For further extensions with this activity, try the following:

1. Ask the students to discover if tomatoes will work and reason why or why not.
2. Compare the size of fruits and vegetables to the length of time that the bulb stays lit.
3. Have the students test the fruits and vegetables for pH levels and compare the pH levels to the amount of electricity generated.

Teacher Background

Fruits do not store electricity like batteries. You can use the chemical properties of certain fruits and vegetables to generate electricity. A lemon, for example, can be made to power a very small electrical device due to its high acidic content. By placing the zinc and copper electrodes into the lemon, you are able to draw electrical power from the lemon through an external circuit and do work. A lemon is equivalent to a calculator battery. The chemistry of a lemon cell is that zinc is an active metal that reacts readily with acid. A transfer of electrons takes place between the zinc and the acid. The copper electrode is used to draw power from the lemon cell by helping to channel the electrons through the external circuit. This sort of cell will work for any fruit or vegetable with some acid content. For a more detailed explanation on the chemistry of fruit batteries go to http://www.madsci.org/experiments/archive/889917606.Ch.html

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Battery Tester

Purpose

Students will be able to create a tester to test batteries.

Procedure

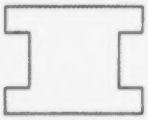

Diagram 1

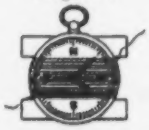

Diagram 2

Diagram 4

Diagram 6

1. Place the compass on the cardboard as shown in diagram 2. Using the **uninsulated** copper wire, lash compass to the cardboard 15-20 times, leaving 5 cm of wire on each end.
2. Screw one of the screws in a corner of the balsa wood. Screw the second screw in the diagonal corner. Attach washers to the back of the screws to hold them in place. See diagram 3.

Diagram 3

3. On a flat surface, place the compass on the balsa wood with compass face up.
4. Attach one end of the copper wire that is wrapped around the compass to the top screw and then attach the other end to the bottom screw. See diagram 4.
5. Strip 5 cm of insulation from each end of the two insulated copper wires. See diagram 5.

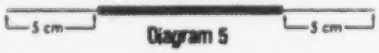

Diagram 5

6. Attach one end of one of the insulated wires to an alligator clip and the other end to the paper clip. See diagram 6.
7. Repeat with the other insulated wire, alligator clip, and paper clip.
8. To test the battery, place paper clips on the positive and negative terminals of the battery and then clip alligator clips to the screws on battery tester. See diagram 7.
9. Note movement of compass needle.
11. Record observations in science journal.
12. Continue to test other batteries and compare the amount of movement for each.

Materials (per group)

- 12-cm square of balsa wood
- 2 pieces of **insulated** copper wire 20 cm each
- 9-cm X 5-cm piece of cardboard cut in shape as shown **(see diagram 1)**
- small compass
- enough **uninsulated** copper wire to wrap around compass 15-20 times
- 2 alligator clips
- 2 paper clips
- 2 screws with washers
- screwdriver
- wire stripper
- various batteries any size

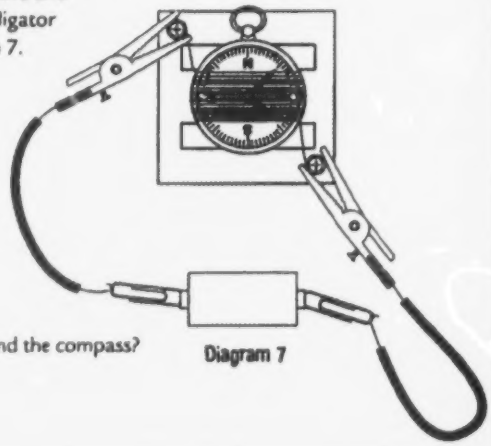

Diagram 7

Conclusion

1. How much of a difference was there in compass needle movement between batteries?
2. Why was there a difference? What are some factors that could cause a difference?
3. Why does the compass needle move?
4. Why was it necessary to wrap the copper wire around the compass?

Extension

Have the students make an electromagnet.

Teacher Background

A battery is a called a dry cell. It consists of a zinc can that contains a moist, paste-like mixture of chemicals. In the center is a solid carbon rod. As a chemical reaction takes place between the zinc and the paste, electrons are released. From the zinc part of the cell is a negative terminal that picks up the electrons as they are created. The carbon rod has a positive terminal that has a shortage of electrons, and this difference in the number of electrons creates an electron pressure that pumps the electrons.

If a wire is connected to each terminal, the electrons flow from the negative terminal through the wire to the positive terminal. As the chemical reaction continues, the electrons are pumped back to the negative terminal of the dry cell. A steady flow of current is created. An electric current flowing through the coil wire produces a magnetic field which acts in a single direction. It is the magnetic field that is created by the flowing current in the wire wrapped around the compass that makes the compass needle move because the coil acts like a permanent magnet. The strength of the magnetic field flowing around a current-bearing wire is proportional to the current flowing in the wire.

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Solar Cell Simulation

Purpose To simulate sunlight striking a solar cell.

Materials

large open area such as a playground or field

chalk or duct tape to outline areas

1-2 bells

30 feet of thick rope knotted on each end

Procedure

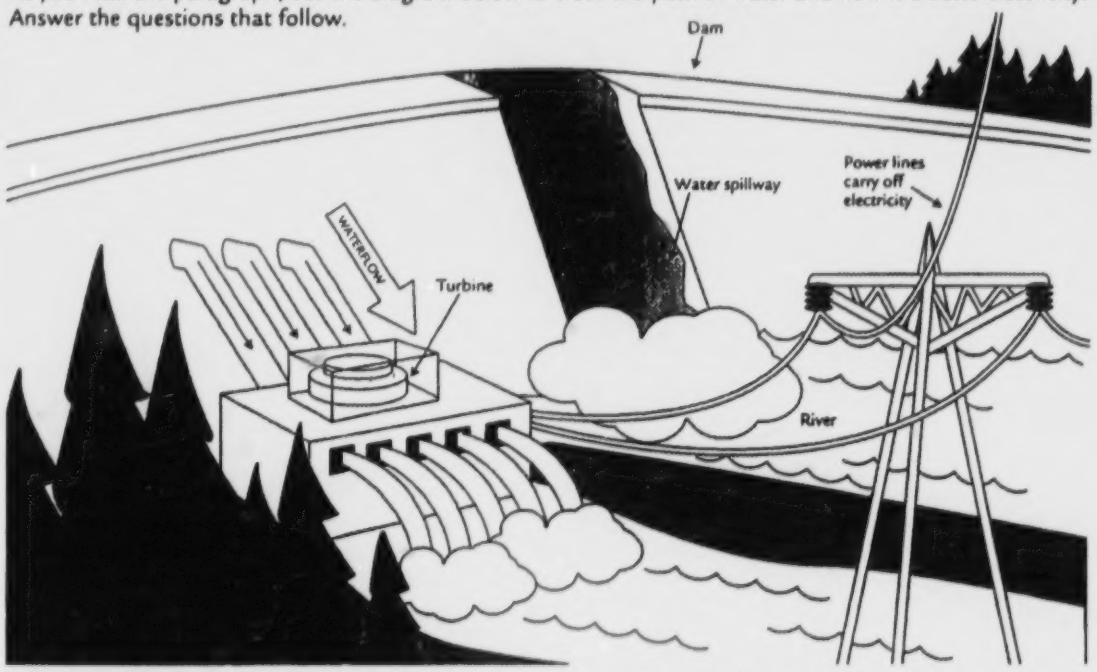
1. Prior to the simulation, the teacher should outline an area on the ground approximately 3 m by 3 m to represent the solar cell.
2. To represent the sun, outline another area as a large circle approximately 5 m in diameter 10-15 m from the solar cell.
3. Discuss with the class the definition of a simulation.
4. Divide the class in half, with one half standing in the solar area (square area) and the other half standing within the Sun (circle area).
5. Have the students in the solar cell grasp onto the rope spacing themselves about 1/2 m apart. Have one end of the rope lie outside the cell and attach the bells to its end to represent the "load" that is being powered by the solar cell. Explain that the students in the solar cell are representing electrons, and the rope represents the wire that electrons travel along.
6. Explain that the students in the Sun are representing photons emerging from the Sun.
7. To begin the simulation, choose one photon to leave the Sun and tag the first electron at the end of the rope opposite the bells.
8. Never letting go of the rope, the "tagged" electron will then move up the rope to tag the next electron. That electron will then tag the next one, and so on until the final electron at the end of the rope has been tagged. Then he/she will ring the bell.
9. Meanwhile, other photons should leave the Sun in an orderly fashion, tagging the last electron and repeating the steps above to create a "chain reaction" that simulates a flow of current created by the photons of the Sun.
10. Continue until all photons have left the Sun.
11. Discuss the simulation with the students.

Conclusion

1. Are there extra photos in a real solar cell? If so, what happens to them?
2. What would happen if the photons entered the cell and did not connect with the wire?
3. What would happen if the photons stopped coming?
4. Explain what would happen if you put several solar cells together.
5. Explain how to simulate a cloudy day?
6. Draw a diagram that represents the simulation that you did.

Hydroelectric Power

As you read the paragraph, use the diagram below to trace the path of water and how it creates electricity. Answer the questions that follow.



Water can be used to make power or energy. Electric power made by falling water is called hydroelectric power. To make hydroelectric power, companies build dams to control the flow of water. The water stays trapped behind the dam until the gates of the dam are opened. As the gates open, the water rushes down and turns the wheels of a turbine. As the wheels turn, they drive machines that make electric power. This power is then sent through power lines to many places to light buildings, run machines, heat homes, and much more.

1. Must a dam be built to produce hydroelectric power? Why or why not?

2. Why is the power station located below the dam?

3. Explain what you think renewable energy means.

4. In what way would hydroelectric power be a renewable energy source?

Extension

Research hydroelectric power plants and identify the following information:

- location
- benefits of hydroelectric power
- total water used
- potential energy stored by the plant
- present day uses of the energy created by the plant
- any other items of interest

Hydroelectric Power Plants
Niagara
Itaipú
C. H. Corn
Grand Coulee
Chief Joseph
Hoover
Oroville

Check out the NASA "Why?" Files web site, **http://whyfiles.larc.nasa.gov** for helpful internet links to get you started!

Water Turbine

Purpose

To demonstrate the movement of a water turbine as used in a hydroelectric power plant.

Materials (per group)

- science journal
- 2 sewing pins
- felt tip pen
- utility knife (boxer opener)
- ruler
- cork
- scissors
- glue
- tape
- plastic straw
- cardboard 20 cm X 12 cm or larger
- stop watch or clock

Procedure

Diagram 1

1. Using a felt tip pen, mark two lines across the center of the top of a cork to create an X.
2. Use a ruler to draw the lines down the sides of the cork from the four points of the X. See diagram 1.
3. With Adult Supervision: Use a utility knife to score along the lines so that the cut is about 1cm deep.
4. From the cardboard, cut out four equal rectangles that measure 5cm x 3cm. Color one rectangle a dark color to contrast with the other rectangles.
5. Insert one rectangular cardboard piece into each cut along the cork. See diagram 2. If the cardboard does not stay firmly in the cut line, carefully place a little glue in the scored line area and then insert the cardboard, holding it firmly for about 30 seconds.

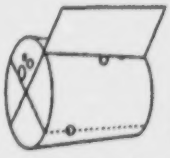


Diagram 2

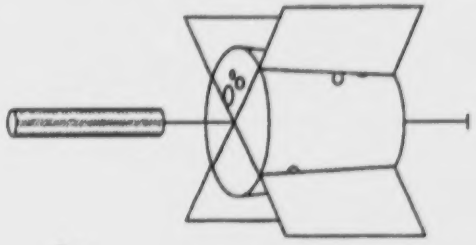
6. Place a pin at either end of the cork. The pins will be the axes for the turning motion of the cork.
7. Cut two 5-cm lengths of plastic straw and place on either end of the cork so that the pin sits inside the straw. This will provide stability and free motion of the cork. See diagram 3.
8. Holding onto the straws at each end, place the turbine you have created under a running stream of water such as a sink faucet. Observe how the cork spins as the water runs over the cardboard water wheel. Record your observations in your science journal and draw a diagram of your design.
9. Place the turbine under a steady stream of water and count the number of rotations in one minute. Record in your science journal.
10. Increase the flow of the water so that it is flowing just a little faster than before. Repeat Step 9 and record.
11. Decrease the flow of water to a trickle. Repeat Step 9 and record.

Conclusion

1. How did the number of rotations of the turbine differ with the various streams of water?
2. Explain why they differed.
3. If you were to design a hydroelectric power plant, how would this information help you?
4. Why would an engineer want to increase the number of rotations per minute of the turbine in a hydroelectric power plant?
5. Other than increasing the speed of water, is there any other way that you could increase the number of rotations per minute of the turbine? Explain.

Extensions

1. Create a hydroelectric power plant and use the water turbine you created as part of the design.
2. Change the size or shape of the cardboard pieces to determine what effect, if any, they will have on the number of rotations per minute of the turbine.



29

Diagram 3

Fun with Wind

Objective

To give students experiences with exploring wind as a renewable energy source.

Materials

- 4 small paper cups (3-oz size)
- scissors
- ruler
- stapler
- push pin
- pencil with sharp point and eraser
- modeling clay
- dark colored marker
- 2 strips of corrugated cardboard each 22 cm X 5 cm
- science journal
- tape (optional)
- pie pan or cookie sheet (optional)

Procedure

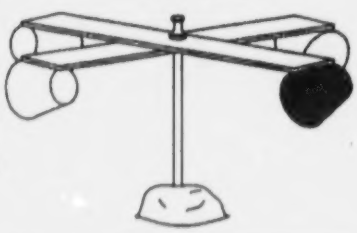
Diagram 1.

1. To create the cups for the anemometer, you will need to cut the rolled edges off to make the cups lighter.
2. Color the outside of one cup with a marker.
3. Using the ruler, measure 11 cm from one end of each cardboard strip and draw a line to mark the distance.
4. Line the two cardboard strips up on that line so that they make a plus (+) sign. (See diagram 1.)
5. In the middle section where the two strips overlap, use the ruler and pencil to draw lines from the outside corners to the opposite corners. These lines will create an "X." The exact center is where the lines intersect.
6. Push the push pin through the center of the "X" on the cardboard strips to connect them. Staple or tape strips in place.
7. Making sure that all the cups face the same direction, staple one cup to the end of each strip.
8. Place the push pin through the top of the pencil eraser. Check to make sure the cups spin freely by blowing on them. If they do not spin freely, then you may need to adjust the size of the hole in the cardboard. (See diagram 2.)
9. For a stationary model, you may place the modeling clay outside on a smooth surface and then insert the sharpened end of the pencil into the clay. If you would like a more mobile anemometer, you may want to place the clay on a smooth flat surface of an object, such as a pie pan or cookie sheet that can be transported from one place to another.
10. Your anemometer is now ready to use. You will need to go outside to an open area.
11. Your anemometer cannot measure wind speed in miles per hour, but it can give you an approximation of how fast the wind is blowing.
12. To measure the wind speed, place your anemometer in an open area and observe to see if your cups are spinning. If they are, then use your watch and count the number of times the colored cup spins around in one minute. This method measures the wind speed in revolutions (turns) per minute. Record your data in your science journal.
13. Repeat measurement in other areas of the playground/school yard. Record your data, keeping a chart of all the areas where wind was recorded.

Conclusion

1. Was it windier in some places on the playground than in others? Why or why not?
2. How would trees or buildings affect the speed of wind?
3. How do you think a wind turbine would compare to a water turbine at a hydroelectric power plant?
4. Would wind be a good source of energy? Why or why not?
5. Where would you build a wind turbine in the U.S.? Why?
6. Research renewable energy and discuss whether wind would be considered a source of renewable energy.

Diagram 2.



Teacher Background

Wind turbines are machines that change the movement of wind into electricity. They need a constant, average wind speed of about 14 mph before the wind turbines can generate electricity. In a wind farm there are a lot of turbines grouped together in windy spots of the United States. These wind farms provide an alternative source for energy and have some advantages over other conventional types of energy. Wind farms are located in three places in California: Altamont Pass, Tehachapi, and San Gorgonio. Have your students research wind farms. They might be surprised to find other locations that have wind farms!

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Sun Cooking with a Chance of Rain

Purpose

Using solar energy, the students will discover how color affects the absorption of heat.

Procedure

1. Line the inside of the umbrella with Mylar* using tape to hold in place.
2. Place the umbrella outside in a sunny place around 11:00 AM. Make sure no shadows will be over the cooker.
3. Have the students explain how they think the umbrella cooker will get hot.
4. Ask the students if they think any particular spot on the umbrella will be hotter than other spots. Have them explain their reasoning.
5. Explain that the cooker will have a hot spot due to its shape.
6. To locate the hot spot, have the students move their hands around the perimeter and across the inside of the cooker until they find the hottest area. Once the hottest area is found, have the students raise their hands slowly until they reach the hot spot, which is usually really hot! They will roast their marshmallows at this spot.
7. Have the students choose 3 different colored marshmallows and 3 pieces of spaghetti.
8. Use the spaghetti to skewer each marshmallow.
9. Have the students take turns roasting each marshmallow and timing how long it takes. Record roasting times in science journal.
10. Eat marshmallows and discuss results.

Materials

umbrella

enough silver Mylar* to line the inside of umbrella (collect used Mylar* balloons and cut balloons apart to use the Mylar* for lining)

tape

flavored marshmallows (they must be different colors)

uncooked thick spaghetti noodles

a clear sunny day

watch or stop watch

science journal

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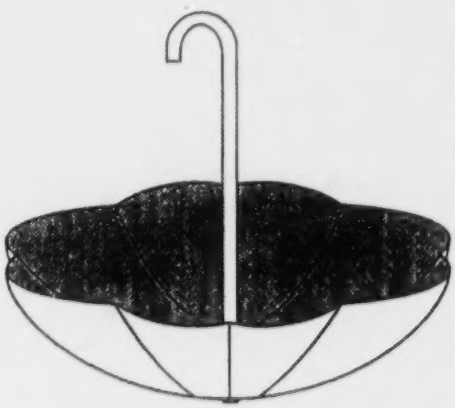
Conclusion

1. What color roasted the fastest? Why?
2. If you were to build a solar cooker, what color do you think would be the best color to use to roast or cook food the fastest?
3. Did any color not roast? Why or why not?

Extensions

1. Design other types of solar collectors. Test to see which one will cook the fastest. Create a competition among groups.
2. Design a solar collector to hold water and test to determine how fast it will heat water by measuring water temperature in 15-minute intervals.
3. Solar energy is a renewable energy source that has many benefits for our environment. Have students research and discuss the benefits.



Teacher Background

Parabolic solar collectors collect the light rays of the Sun. Because the shape of the collector is parabolic, the light rays come together at a point above the collector. This point is called the hot spot, and that is why the students had to raise their hands up from the hottest area. The location of the hot spot will vary based on the location of the Sun.

The darker the color of the marshmallow, the faster the cooking time. Based on absorption of heat (darker colors absorb more heat), chocolate marshmallows will cook the fastest, while white marshmallows will never roast. The white color will not absorb enough heat to roast. As students discover darker colors absorb more heat, they should then be able to conclude that a solar cooker would work best if built from dark (black) colored materials.

Answer Key

Fruity Energy

1. Acidic—tends to form an acid, and acidic fruit will have a sour taste. Oranges, lemons, and grapefruits are acidic.
2. Yes
3. Answers will vary depending on fruit used.
4. Only some of the fruits were acidic.
5. Some were brighter than others.
6. Bulbs will glow brighter the more acidic the fruit is
7. Answers will vary.

Battery Tester

1. Answers will vary.
2. Some batteries may have been creating a stronger electrical current. Other factors might include the number of times the wire is wrapped around the compass, the type of battery tested, temperature, or the age of the battery.
3. The compass needle moves because of the magnetic field created by the flowing current through the wire wrapped around the compass.
4. It was necessary to wrap the wire around the compass to create a magnetic field strong enough to move the needle. The more wraps of copper wire around the compass, the more sensitive the battery tester.

Solar Cell Simulation

1. Yes. The materials in the solar cell absorb extra photons.
2. There would not be a flow of electricity created.
3. The solar cell would not create any power.
4. Several solar cells would create a stronger electrical current.
5. For a cloudy day simulation, some of the photons would scatter and not reach the solar cell, thus simulating the Sun's being reflected and absorbed by the clouds.
6. Drawings will vary.

Hydroelectric Power

1. Dams are built to hold large quantities of water that can be released as needed to create electricity. If a dam were not built, the flow of water would be too little to create a large amount of electricity. Dams also help to control the flow of water during seasons that do not have as much rain.
2. The power station is located below the dam so that the falling water will create a greater force, which will turn the turbines faster.
3. Answers will vary.
4. Water is considered a renewable source of energy, and students might explain the water cycle as part of their answer.

Water Turbine

1. With a slower stream of water, the turbine did not have as many spins in a minute as it did with a faster stream of water.
2. The spins differed because the water supplied the force to spin the turbine. If the water flowed faster, it had more force; therefore, the turbine would spin faster.
3. Answers will vary but should include that an engineer would want to design a hydroelectric power plant so that the turbines would spin the fastest. This might be due to the position of the turbines in relationship to the water falling, the amount of water in a river or released from a dam, or even the location of the plant.
4. Engineers would want to increase the number of revolutions in order to create more mechanical energy that could then be converted into electricity.
5. Answers will vary.

Fun with Wind

1-2. Answers will vary. A few reasons for possible windier conditions in some areas of a playground would be the lack of trees or buildings blocking the wind. Another consideration would be if there is an area that creates a "channel" that air flows through (space between two buildings). With a channel, the wind will flow faster as it is forced between the two structures.

3. Both have wheels that turn to create electricity.
4. Answers will vary. Wind is considered a good source of energy if you live in an area that has a sustained wind speed of at least 14 mph. Energy created by wind is clean and good for the environment.
5. Answers will vary.
6. Answers will vary.

Sun Cooking with a Chance of Rain

1. The darkest color should have roasted in the least amount of time because dark colors absorb more heat.
2. A dark colored one such as one made from black materials.
3. White will not roast because it cannot absorb enough heat. White is a reflective color, not an absorptive color such as black, brown, or other dark colors.

To There and Back

1. Answers will vary.
2. Answers will vary.

The NASA "Why?" Files
The Case of the Electrical Mystery

Segment 3

The tree house detectives continue their quest for the solution to the case of the electrical mystery. Because they are eager to go swimming in their neighbor's pool, the tree house detectives hope that the lesson being taught in school will give them the clues they need to solve the case. At school, a NASA Langley Research Center researcher shows the class how to identify the basic components of a circuit (conductor, load, and power source) and how to create simple, open, and closed circuits. The tree house detectives apply their new knowledge to the problem but discover they need to know more about complex circuits. They e-mail the NASA "Why?" Files Kids Club and find a Montreal, Quebec, class that has performed experiments on series and parallel circuits. After reviewing what the Montreal students have discovered about complex circuits, they feel that they are better prepared to find the solution. A KSNN report informs the tree house detectives that the power company claims all lines are repaired and that all main circuits appear to be working. Once again, they revise their hypothesis. The tree house detectives are getting closer to the answer, but will they ever get to swim in Mr. E's pool?

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Objectives

Students will
- name the basic components of a circuit (power source, conductor, and load).
- identify and create open, closed, simple, complex, series, and parallel circuits.
- understand how a circuit can be overloaded or short circuited.
- identify the devices (fuses and circuit breakers) used to prevent fires when circuits overload or short circuit.

Vocabulary

circuit breaker - a switch that flips open when the current flow becomes too high, thus breaking the circuit and stopping the flow

closed circuit - a closed path that allows electrons to flow

complex circuit - a circuit that has more than one component

conductors - material that permits electric charges to move easily

fuse - a device containing a thin metal strip that melts and breaks the flow of electricity if the current becomes too high

load - the device that uses the electricity, such as a lightbulb

open circuit - a path that has a break; therefore, electrons cannot flow

parallel circuit - electric circuit in which the different parts of the circuit are on separate branches

resistor - a substance or device that prevents the electrical current from flowing

series circuit - an electric circuit in which all parts of the circuit are connected one after another

simple circuit - a basic circuit consisting of three elements: the conductor (wire), the load (object that uses the electricity), and the energy source (battery or other power source)

switch - a device in an electric circuit that opens and closes the circuit

transformer - a device that increases or decreases the voltage of alternating current

volt - unit of measurement symbolized by the letter "V"

voltage - measure of energy available to move electrons; the push that makes the electrons move

Video Component (15 min)

Before Viewing

1. Briefly summarize and discuss the events in segment 2 with the students.
2. Review the K-W-L chart that the class created earlier (p. 11). Continue to add items in the third column "What have you **learned**?" Are there other ideas you would like to add to the "What do we **want** to find out" list?

3. To assess your students' knowledge about circuitry, use the worksheet, *Light the Bulb*, in the activities section of the guide (p. 39). Have students make predictions about which circuits will light the bulb. Making predictions is central to science and research and can be used to assess thinking and learning. Have students save their prediction sheets for use later.

After Viewing

1. Discuss the questions that are asked at the end of the segment.
   - Why do you think the power is still off across the street?
   - Is an "open circuit" keeping Dr. D's train from working?
   - Do you think the tree house detectives are getting closer to solving the case?
2. Continue working with the display board to reinforce the investigative steps that the tree house detectives are taking to solve the problem. Point out that the detectives frequently stop to summarize what they know and discuss what they need to know. They also revise their hypothesis.
3. Select activities from this lesson guide and the web site to reinforce making circuits.
4. Have students revisit their predictions about simple circuits, *Light the Bulb* (p. 39). Revise predictions as appropriate. Have them analyze similar circuits in a new situation and evaluate their understanding of what is needed to complete a simple circuit.
5. Review the vocabulary and have students write sentences using the vocabulary correctly.
6. Continue updating the display board to reinforce the processes used by the tree house detectives to solve the problem.
7. As a class, hypothesize possible reasons why the houses across the street are still without power. Why doesn't Dr. D's train set work? How does Dr. D show that he uses logical thinking and the components of a good science investigation?
8. Assess students' knowledge of circuits and review if necessary.

Careers

electronics engineer

electronics engineering technician

electromechanical engineer

electromechanical engineering technician

Resources

Books

Brown, Janet Harley and Shavelson, Richard J.: *Assessing Hands-On Science: A Teacher's Guide to Performance Assessment.* Corwin, Pr., 1996, ISBN 0803964420

Dispezio, Michael: *Awesome Experiments in Electricity and Magnetism.* Sterling Publishing Company, Incorporated, 1999, ISBN 0806998199

Graf, Rudolf F.: *Safe and Simple Electrical Experiments.* Dover Publications, Incorporated, 1991, ISBN 0486229505

Hein, George and Price, Sabra: *Active Assessment for Active Science: A Guide for Elementary School Teachers.* Heinemann, 1994, ISBN 0435-083619

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Web Sites

Kids Schoolhouse
A student web site about energy and electricity that makes the "classroom" fun. The on-line classroom includes a homeroom, a history class, a science lab, field trips and much more.
http://www.EnergyMatch.com/schoolhouse/

The Shocking Truth about Electricity
The site was created by kids and entered into the ThinkQuest Junior web site contest for 2000! The topics included in the site are History of Energy, About Electricity, Power Failures, and Circuits. Home experiments, an on-line quiz, and other related internet resources are provided.
http://tqjunior.advanced.org/6064/

NASA "Why?" Files Web Site
Official web site of the NASA "Why?" Files. Student, teacher, and parent friendly.
http://whyfiles.larc.nasa.gov

Activities and Worksheets

In the Guide

Light the Bulb 39
Assesses students' knowledge about circuitry.

Series Circuits 40
Guides students in making series circuit.

Parallel Circuits 41
Guides students in making parallel circuits .

Conductors and Insulators 42
Students explore different types of materials to determine which are good insulators and which are good conductors.

Tap, Tap, Tap: Telegraphs and Morse Code 43
Students construct a telegraph system and learn how electricity is used as a form of communication as they use Morse Code.

Drawing Circuits 45
Students make schematic drawings to create their own circuits to be tested.

Switch, Switching, Switches 46
Students build four different types of switches and discover how a switch functions to open and close a circuit.

Answer Key 48

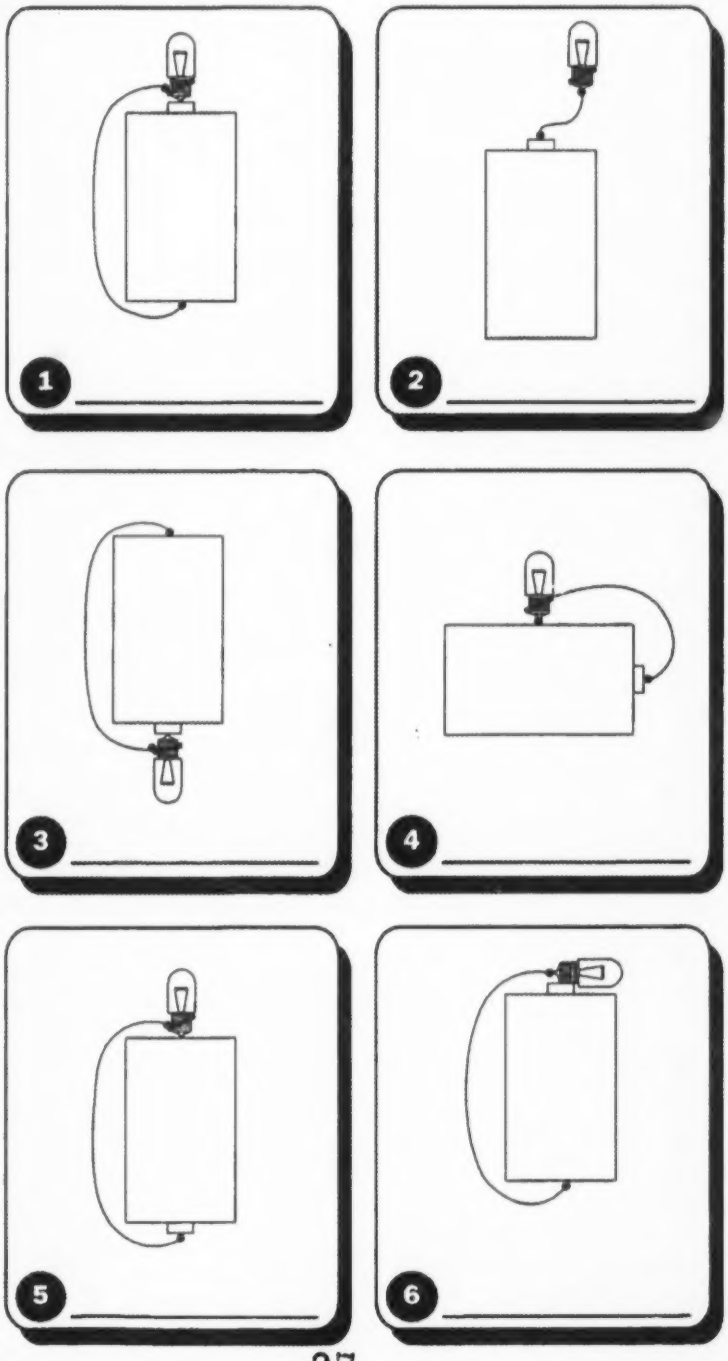
On the Web

You can find the following activities on the Web at http://whyfiles.larc.nasa.gov.

Circuit Construction Exploration
Students explore creating circuits to discover the difference between series and parallel.

Light the Bulb

Will the bulb light? Below each picture, make your prediction by writing either "on or "off."



Series Circuits

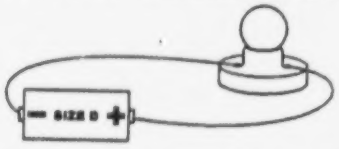
Purpose To give students an opportunity to explore series circuits.

Materials

- 2 D cell batteries
- 2 D cell battery holders (optional)
- 2 lamps (bulbs)
- 2 lamp holders
- 4 pieces of insulated wire 25-30 cm long with ends stripped off

Procedure

1. Create a circuit as illustrated below.

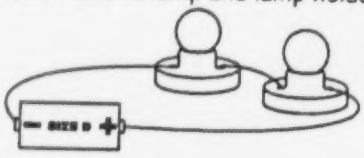


2. Describe the brightness of the bulb. _____

_____

_____

3. Add a second lamp and lamp holder, as illustrated, and connect the battery.



4. How did the brightness change? _____

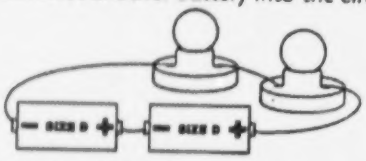
_____

5. Unscrew one of the lamps and describe what happened to the other lamp. _____

_____

_____

6. Connect another battery into the circuit as illustrated below.



7. Describe the brightness of the lamps. _____

_____

8. Write a definition of a series circuit and draw a diagram. _____

_____

In a series circuit, each lamp is dependent on all the other lamps for a complete circuit. When batteries are connected in a series, the voltage in the circuit is increased by each added battery. For example, two 1 1/2 -volt batteries act as one 3-volt battery.

Parallel Circuits

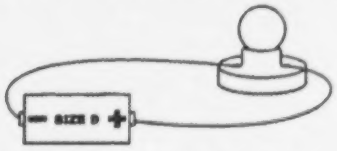
Purpose To give students an opportunity to explore parallel circuits.

Materials

- 2 D cell batteries
- 2 D cell battery holders (optional)
- 2 lamps (bulbs)
- 2 lamp holders
- 6 pieces of insulated wire 30 cm long with ends stripped 2 cm

Procedure

1. Create a circuit as illustrated below.

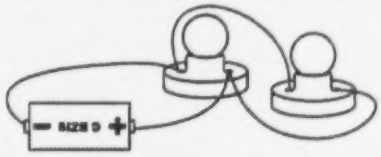


2. Describe the brightness of the lamp. _____

_____

_____

3. Add a second lamp to the circuit as illustrated.



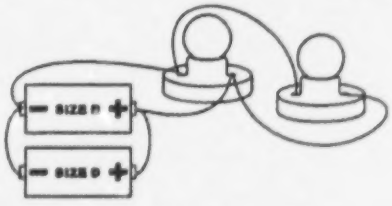
4. How did the brightness change? _____

_____

5. Remove one of the lamps. What happened to the other lamp? _____

_____

6. Connect a second 1 1/2-volt battery in parallel as illustrated.



7. How did the brightness change? _____

_____

In parallel circuits, each lamp receives the full voltage produced by the battery. Batteries can also be connected in a parallel arrangement. When two 1 1/2-volt batteries are connected in parallel, they will only produce 1 1/2-volts for the circuit. They will, however, cause the lamps to burn twice as long before the batteries wear out.

Conclusion Draw a parallel circuit and explain the flow of the current. Explain what happens when you remove one of the lamps from a parallel circuit.

Conductors and Insulators

Purpose

Students will discover which types of materials make good conductors of electricity and which types are good insulators.

Materials

D cell battery
(Per group)
D cell battery holder
lamp
lamp holder
3 pieces of insulated wire 30 cm long with ends stripped 2 cm
various objects for testing such as wooden pencil, penny, aluminum foil, paper strip, plastic pen, metal pen, and so forth

Procedure

1. To create a simple conductivity tester, place the battery in the battery holder and connect a wire to each end of the holder.
2. Make sure the lamp is screwed into the lamp holder and connect the wire from the positive terminal of the battery holder to one of the contacts on the lamp holder.
3. Connect the third wire to the other lamp holder contact. You now have two wires that are not connected. See Diagram 1.

Diagram 1

The ends of the two wires are the open leads, and they will be used to test the objects.

4. Conduct a test to make sure that your setup is working. Touch the two open leads to each other. If setup is working, the lamp will light.
5. To test objects, touch the ends of both open leads to the object, forming a complete circuit. If the lamp lights up, the material the object is made from is considered a conductor. If not, the material is an insulator.
6. Begin your test of objects and fill in the chart below. As you discover conductors, observe the brightness of the lamp.

Object Tested	Conductor Insulator	Brightness of Lamp

Conclusion

1. What did the objects that were conductors have in common? _____
2. What conclusion can you make? _____
_____
3. Name five other objects that are conductors of electricity. _____
_____
4. How did the brightness of the lamp vary between conductors? Explain. _____
_____

Assessment

For class assessment of learning, place objects on a table and have the class sort the objects into two piles and label each pile as either conductors or insulators. Have the students explain their choices. For small group assessment, a shoe box filled with various objects could be sorted, with students writing explanations in science journal.

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Tap, Tap, Tap: Telegraphs and Morse Code

Purpose

To give students an opportunity to build a telegraph, use Morse Code, and learn an effective use for electricity.

Materials

6-volt lantern battery
lamp in lamp holder
10 m of insulted wire
wire cutters/strippers
Morse Code Sheet

Procedure

1. Cut the wire in half and strip 2-3 cm of insulation from the end of each piece.
2. Connect one end of each wire to the lamp holder connections. See Diagram 1.
3. Connect one end of one wire to the positive terminal of the battery, but do not connect the other wire. See Diagram 2.
4. With the end of the wire that is not connected, touch the negative terminal to see if your lamp lights up (to test the telegraph).
5. Place the lamp in one area of the room and the battery in another area of the room.
6. Your partner and you are now ready to send messages. Decide who will be the "sender" and who will be the "receiver."
7. The "sender" will first write his/her message in English, then use the code sheet to translate it into a series of dots and dashes.
8. To send the message on your telegraph, you will need to follow these rules:
   - Make a dash by holding the battery connection for one full second.
   - Make a dot by just touching the battery connection and removing it immediately.
   - Pause two full seconds between letters and four full seconds between words.
9. When receiving a message, first copy the message in dots and dashes, then use the Morse Code sheet to translate it back into English.
10. Compare the messages both sent and received. Do they match closely?
11. Switch jobs with your partner and repeat sending a new message.

Extensions

1. This telegraph system only works in one direction. How might you change it so you both could send and receive messages? What additional parts would you need?
2. In a Morse telegraph system, operators used a telegraph key that was a type of switch that allowed them to open and close the circuit much faster than taking a wire on and off a battery. Design a telegraph key for your telegraph system using such items as paper clips and brass paper fasteners. Draw a diagram first and then test your idea.
3. Design your own secret code and practice using it with your telegraph.

Diagram 1

Diagram 2

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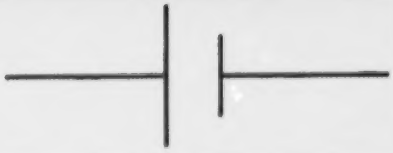
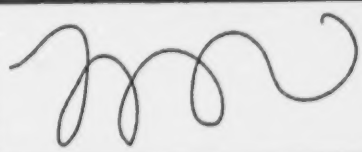
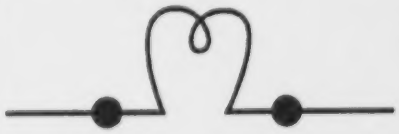
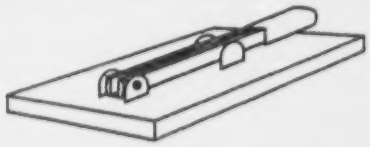
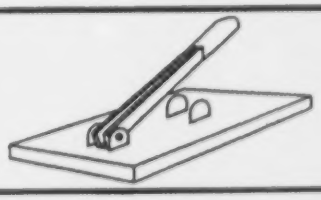
Morse Code

In 1838, Samuel Morse developed a system of dots and dashes to translate messages to and from English. This system became known as "Morse Code." In 1840, he strung a line from Washington, D.C to Baltimore, Maryland and sent the message "What hath God wrought?" to demonstrate that his telegraph and Morse Code would work. He was successful, and soon telegraph lines were strung across the country. The chart below is a Morse Code conversion chart for you to use in writing and decoding your messages.

A • –	T –
B – • • •	U • • –
C – • – •	V • • • –
D – • •	W • – –
E •	X – • • –
F • • – •	Y – • – –
G – – •	Z – – • •
H • • • •	
I • •	
J • – – –	1 • – – – –
K – • –	2 • • – – –
L • – • •	3 • • • – –
M – –	4 • • • • –
N – •	5 • • • • •
O – – –	6 – • • • •
P • – – •	7 – – • • •
Q – – • –	8 – – – • •
R • – •	9 – – – – •
S • • •	0 – – – – –

Drawing Circuits

Many electricians and electrical engineers use a symbolic language called a schematic to draw a circuit. The chart below shows some schematic symbols commonly used in electricity experiments. Use these symbols to draw several different circuits and then try building the circuits to match.

Component	Picture Schematic	Lamp (bulb)
Dry Cell		
Wire		
Lamp Bulb		
Lamp Bulb in Socket		
Switch (open)		
Switch (closed)		
Fuse		

Switch, Switching, Switches

Purpose

Students will discover how a switch works to open and close circuits.

Background

The students will be making and testing four different types of switches. They will make the four switches but will have only one battery setup. If possible, it would be ideal for all four switches to have their own battery. You may wish to have each group build a different type of switch and then demonstrate and discuss their design.

Materials

4.5-volt battery
lamp
lamp holder
3 pieces of insulated wire 30 cm long with 2 cm stripped from each end
4-5 paper clips
2 strips of tinfoil approximately 3 cm X 10 cm each
2 thumbtacks
1 thin strip of copper approximately 3 cm X 12 cm
1 thin strip of copper approximately 3 cm X 5 cm
3 pieces of balsa wood approximately 5 cm X 10 cm
1 piece of cardstock approximately 5 cm X 20 cm
pliers
slice of cork
2 alligator clips
lead pencil split open to reveal the lead center (ADULT—soak pencil in water and slice it down the middle using a sharp knife.)
tape
glue

Procedure

Battery Setup

Diagram 1

1. Attach a paper clip to one end of a wire and then attach the paper clip to the positive terminal of the battery.
2. Repeat with second wire, attaching paper clip to the negative terminal of the battery. Attach the other end to the lamp holder.
3. Attach third wire to the other connector on the lamp holder. See diagram 1.

Diagram 2

Simple Switch

1. Place a paper clip in the center of one of the pieces of balsa wood.
2. Push a thumbtack into an open end of the paper clip to hold it in place, and place the other thumbtack at the edge of the other end of the paper clip. Do not place it inside the open end. It should be able to slide back and forth. See diagram 2.
3. Attach the end of the wire from the positive terminal to one of the thumbtacks and then attach the end of the wire from the lamp holder to the other thumbtack. See diagram 3.
4. Slide the "switch" (paper clip) away from the thumbtack to open the circuit and then slide it so that it touches the thumbtack to close the circuit. Record your observations in your science journal.

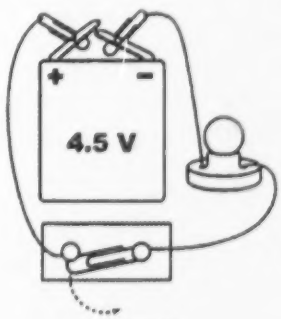


Diagram 3

Pressure Switch

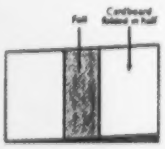


Diagram 4

1. Fold the cardboard in half.
2. Wrap one strip of foil around the middle of one side of the folded cardboard. Repeat with the other strip of foil for the other side of the cardboard. Strips must meet when pressed together. You may use a small piece of tape to hold foil in place. See diagram 4.
3. Tape the end of the wire from the positive terminal to one side of the cardboard on the outside.
4. Tape the end of the other wire from the negative terminal to the other piece of cardboard on the outside. See diagram 5.
5. Press the cardboard so that the strips touch to create a closed circuit. Observe the lamp. Record your observations in your science journal.

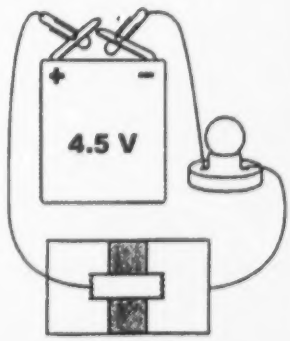


Diagram 5

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Switch, Switching, Switches (continued)

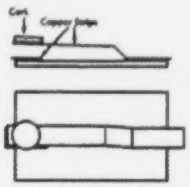

Diagram 6

Tapper Switch

1. Glue the short strip of copper to one end of the balsa wood so that it hangs over the edge a little.
2. Using pliers, bend the long strip of copper to match the shape in diagram 6 and glue into place.
3. Glue a slice of cork to the top of the straight end of the long copper strip.
4. After the glue has dried, attach the end of the wire from the positive terminal to the bent end of the long copper strip.
5. Attach the other paper clip to the end of the short copper strip. See diagram 7.
6. Press the cork so that the copper strips touch and close to form a closed circuit. Observe the lamp and record observations in your science journal.

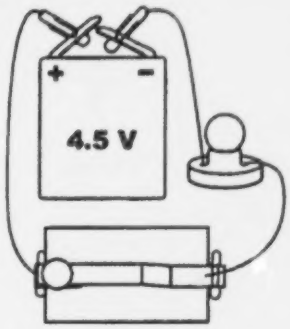

Diagram 7

Dimmer Switch

1. On the battery setup, attach alligator clips to the ends that will be attached to the switch. See diagram 8.
2. Lay the opened pencil on a piece of balsa wood. Attach the alligator clips to opposite ends of the pencil lead.
3. Gradually slide one clip toward the other and observe what happens. Record observations in science journal.

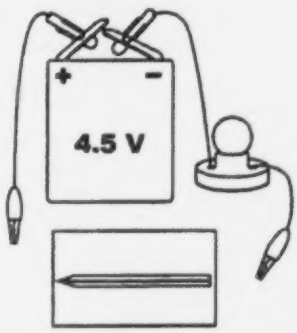

Diagram 7

Conclusion

1. What is an open circuit? A closed circuit? _____

_____

_____

_____

2. Why did the lamp light only during a closed circuit? _____

_____

_____

_____

3. Was there a closed or open circuit in the dimmer switch? Explain what happened as you slid the alligator clips toward each other and tell why. _____

_____

_____

_____

_____

Teacher Background

In a simple switch, the current will flow through the circuit when the circuit is on (closed) and will stop when it is off (open). This is a simple on/off switch that is common in all households and on most appliances. The pressure switch is a type of switch used to make a doorbell ring. Aluminum acts as a conductor; therefore, when the foil strips touch, they complete the circuit and cause the lamp to become lit. A tapper switch is the type of switch used by Morse Code operators. The operator has control over the length of time the circuit is open or closed. When the two copper strips touch, they complete the circuit and will return automatically to the open position (off) when not in use. In the dimmer switch, electricity can pass through the graphite, but not easily. Graphite is a resistor that offers a resistance to the electric current. The farther away the alligator clips are from each other, the more resistance and the dimmer the lamp. The closer the clips come to each other, the less resistance and the brighter the lamp.

Answer Key

Light the Bulb

1. yes
2. no
3. yes
4. no
5. yes
6. no

Series Circuits

2. Answers will vary.
4. The brightness of the lamp decreased.
5. The lamp went out.
7. The brightness of the lamp increased.
8. Answers will vary.

Parallel Circuits

2. Answers will vary.
4. The brightness of the lamp stayed the same.
5. It stayed lit.
7. The brightness of the lamps stayed the same.

Conductors and Insulators

1. Objects that are conductors are made from metal.
2. Metal is a conductor of electricity.
3. Answers will vary.
4. Answers will vary.

Switch, Switching, Switches

1. An open circuit is a circuit with a break in it.
2. A lamp lit only during a closed circuit because the current can only flow in a closed circuit. If the circuit has a break in it, the current would be unable to reach the bulb or return to the battery.
3. Closed circuit. Graphite is a conductor of electricity. However, it does not pass easily; therefore, we say it is a resistor. The farther away the alligator clips are from each other, the more resistance and the dimmer the lamp. The closer they are to each other, the brighter the lamp.

The NASA "Why?" Files
The Case of the Electrical Mystery

Segment 4

It is down to the wire for the tree house detectives as they try to find the solution to the electrical mystery. KSNN reports that the power outage may be due to public damage, but the tree house detectives are not sure what public damage is all about. They meet up with a utility crew to find out, and they also learn about kilowatts, voltage, and how power is measured. When observing Mr. Utility marking lines on a neighbor's property, they conclude that Mr. E did not have his yard marked prior to the installation of his fence. So once again by using scientific investigation, the current facts, and good reasoning, the tree house detectives conclude that Mr. E damaged an underground line and caused the power outage! Finally, they are able to go swimming!

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Vocabulary

kilowatt hour - a measurement of energy that is equal to 1000 watts of power used for one hour

Mister/Miss Utility - a person who provides a service to people wanting to know where power lines are located before they dig in their yards

public damage - damage to a power line that is created by someone other than a utility crew and which causes a power outage

short circuit - a break in the circuit as a result of too much current flowing at once

substation - a branch of a power plant where very high voltage electricity is changed into lower voltage electricity

transformer - a device that converts electricity from a substation into a current and voltage that can be used by homes

Video Component (15 min)

Before Viewing

1. Briefly summarize and discuss the events in segment 3 with the students.
2. Review the K-W-L chart that the class created earlier (p. 11). Continue to add items in the third column, "What have you **learned?**" Are there other ideas you would like to add to the "What do we **want** to find out" list?
3. The tree house detectives are so close to finding the answer to the electrical mystery! Discuss what the tree house detectives might investigate next.

After Viewing

1. Discuss the students' reactions to the solution of the problem for the power outage and Dr. D's train set. Were their predictions correct?
2. Continue working with the display board to reinforce the investigative steps the tree house detectives took to solve the problem.
3. Choose from the activities in this packet and on the web site to reinforce the concepts being emphasized.
4. Have students research how electricity use is measured. Contact your local utility company for information and demonstration equipment.
5. Have students discuss how they can conserve energy in their homes, schools, and other familiar locations.
6. Ask your local utility company about preventing public damage. Research your local contact numbers and precautions that every citizen should know.
7. Research and discuss alternative fuels for power.

Resources

Keen, Dan and Bob Bonnet: *Science Fair Projects with Electricity and Electronics.* Sterling Publisher Company, Incorporated, 1997, ISBN 0806913010

Pratt-Van Cleave, Janice: *Janice Van Cleave's Electricity: Mind-Boggling Experiments You Can Turn into Science Fair Projects.* Wiley, John and Sons, Incorporated, 1994, ISBN 0471310107

Careers

Mr./Miss Utility
lineman
electrician

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Activities and Worksheets

In the Guide

Vocabulary Crossword Puzzle 53
Students use this worksheet to create their own crossword puzzle by using key science vocabulary from this program.

Word Search 54
A word search highlighting key vocabulary terms

Measuring Electricity 101 55
Worksheet to calculate watt hours and kilowatt hours

Electrifying Math 56
Math problem worksheet that teaches students how to make better energy decisions

Electrical Energy Survey 57
Opportunity for students to explore the amount of energy usage among common home appliances

Meter Reader 59
Learn to read a meter and calculate home or school's energy usage.

Answer Key 62

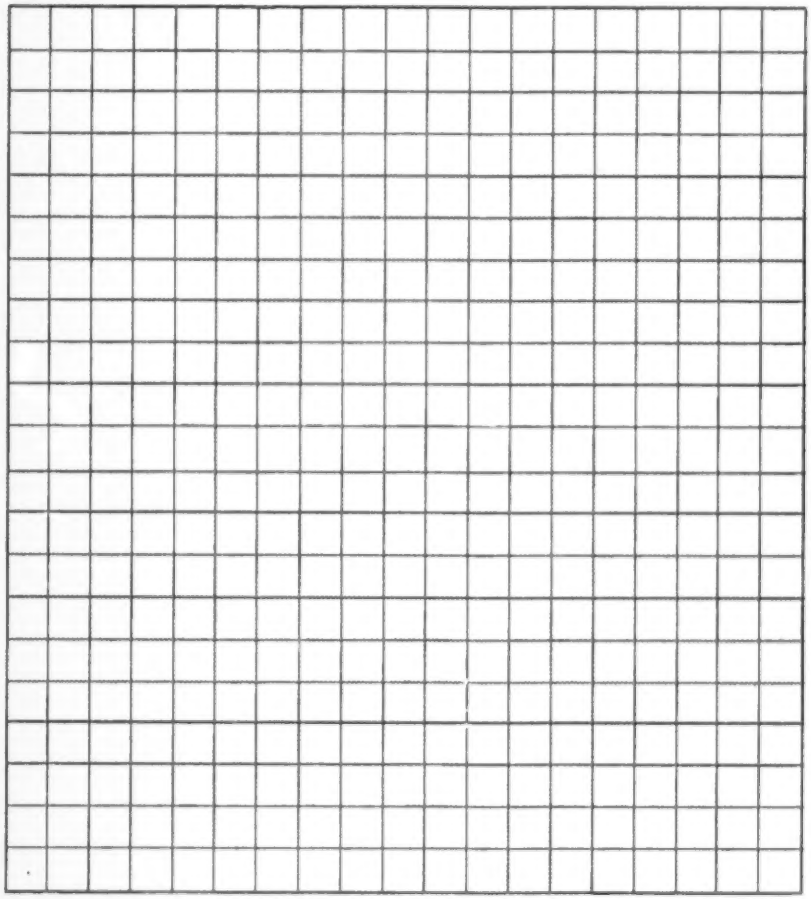
On the Web

You can find the following activities on the Web at http://whyfiles.larc.nasa.gov.

Electricity Concept Map
A concept map that illustrates the major concepts of the video.

Shocking Scientists
Research electrical inventors to learn more about the history of electricity.

Vocabulary Crossword Puzzle



Create a crossword puzzle with the following terms and the grid below.

Vocabulary

circuit
conductor
load
series circuit
switch
insulator
voltage
parallel circuit
electricity
repel
current
kilowatt

Add your own:

_____
_____
_____
_____

Across

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Down

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Word Search

I I L L E C R A L O S O S E C H
F N R E S I S T O R R T A N D Y
I S O X H D K O A S E R I E S D
E U T T N C M A D C T A J R E R
L L C Z Z B T K D L I N N G D O
E A U S T A T I C F U S O Y U E
C T D N E T X L W U C F R V B L
T O N E U T R O N S R O T W Y E
R R O U L E O W C E I R C S P C
I C C H E R H A I E C M E W R T
C Z S U A Y D T Y W V E L N O R
I O T A V O L T A G E R E Y T I
T I R G E N E R A T O R O V O C
Y P A R A L L E L A M O T A N O

battery
circuit
current
energy
generator
kilowatt
load
solar cell
hydroelectric
fuse
conductor
insulator
resistor
series
parallel
switch
voltage
transformer
atom
neutron
electron
proton
static
electricity

Measuring Electricity 101

Most electrically powered devices in your home use different amounts of electricity. The most commonly used unit of energy to measure electricity is the watt. (Note: The watt (W) was named after the Scottish engineer and inventor James Watt.) To measure large quantities of power, such as the power in your home, the kilowatt (kW) is used. A kilowatt (kW) is equal to 1,000 watts of power.

To calculate how much energy a device in your home or school uses, multiply the number of watts the device has by the number of hours the device is used. For example, if you burn a 60-watt bulb for 2 hours, you have used 120 Wh (watt hours). Large quantities of electricity are measured in kilowatt-hours (kWh). One kilowatt-hour is equal to 1,000 watts of electricity used for one hour (1,000 Wh).

Complete the table by determining first the number of watt hours and then the number of kilowatt hours. The first one is done for you.

Appliance	Power (W)	Hours Used	Watts/hour	Kilowatts/hour
Lava lamp	100 W	3 hours	300 Wh	0.3 kWh
Electric Coffee Pot	1500 W	10 hours		
Curling Iron	825 W	4 hours		
Vacuum Cleaner	642 W	60 minutes		
Portable Radio	120 W	120 minutes		
Light Bulb	150 W	90 minutes		

Electrifying Math

In science, the scientific method is a common process used to solve a problem. In mathematics there are also strategies used to solve mathematical problems. Choose a strategy from the chart below to solve the following problems.

Mathematical Strategies

- Choose an operation.
- Make a drawing.
- Use guess and check.
- Make a list.
- Use a chart.
- Use logic.
- Use estimation.
- Work backwards.

1. John and Patrick are not careful about turning off electrical appliances that they are no longer using. John leaves his desk lamp on all day. That 60 W light bulb burns 10 hours a day. What a waste! Patrick leaves his 110 W television on each day from the time he gets home from school at 4 PM until he goes to bed at 9 PM.

   How many watt-hours of electricity does Patrick waste a day?_____

   How many kilowatt-hours do they use combined in a day? _____

   If the utility company charges 10 cents a kilowatt, how much money is spent on these wasteful habits each day? _____

2. Helen and her family decided to reduce their energy consumption, but they need to develop a plan for the household use. They have developed a list of appliances they use each day and the wattage required for each item. Use the data to help them make the most efficient household energy plan.

   It takes 1 hour to cook a potato in an oven and 12 minutes in a microwave. Helen wants to cook a potato for lunch. Which appliance will be the better choice? Why?

   _____

   _____

   Helen's brother wants to read his novel. He normally spends one hour reading each night. He can read in the dinning room or in the living room. Which room would be the best room to read in if he wanted to be energy efficient? Why?_____

   _____

   _____

   Helen's mother washes the family dog once a month. She normally dries the dog's hair with a hair dryer for about 20 minutes. Would it be more efficient to set the dog in front of the fan for an hour? Is the most efficient way always the best? Explain your reasoning. _____

   _____

   _____

   _____

   _____

   _____

Appliance Power in watts (W)

- microwave 1, 500 W
- oven 3, 250 W
- hair dryer 1, 875 W
- chandelier (dinning room) (5) 60 W bulbs
- lamp (living room) 125 W
- television 110 W
- small desk fan 90 W

Electrifying Energy Survey

Purpose To provide students with experience in making observations of electrical energy usage of several appliances in their home.

Materials

data collection sheet
pencil

Before Activity The teacher should prepare a large duplicate of the data collection sheet on bulletin board paper or on the chalkboard.

Procedure

1. Place students in teams of three or four.
2. Distribute the data collection sheets. (See p. 58.)
3. Ask each team member to select 2-4 appliances they would like to investigate in their home. The students will need to be able to find the power usage of each device chosen. You may wish to give this information to the students beforehand.
4. Explain that they will only fill in the first 3 columns of the data sheet. The other two columns will be completed in class when they are brought back.
5. Give the students a time frame (3 days to 1 week) in which to keep track of the daily usage of the appliances they chose. Students should note the due date for the assignment on their data sheets.
6. On the class data collection sheet that you prepared, model a few examples of how to complete the table.
7. Upon completion of the assignment, have the students bring their data collection sheets in and share their data as a class.
8. Record their data on the large class chart. Note: If more than one student collected data on the same appliance, have those students average the data and record only the average on the chart.
9. Discuss the following questions once the data is recorded:
   - Which three appliances use the most electricity?
   - Which three appliances use the least electricity?
   - Which room in the house do you think uses the most electricity?
   - How could you reduce the amount of electricity your family uses?
   - Give students the current rate of electricity per kWh for your area. The rate can be found on your utility bill or by calling the power company.
10. Model how to find the cost per week or month of items on the data sheet.
11. Have students work as a team to determine the cost per month for the appliances their team investigated.
12. As a class, record the costs on the class chart.
13. Once all items have been recorded, discuss the following questions:
    - Which three appliances cost the most to use?
    - Which three appliances cost the least to use?

Conclusion

1. Do all households use the same appliances? Explain why or why not.
2. Explain how households might use appliances for different lengths of time.
3. How could you reduce the cost of your family's electric bill each week/month?

Extensions Give students a power budget of about 5,000 watts per hour. Have them try to get through a typical day without going over their budget.

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Electrifying Energy Survey: Data Collection Sheet

Before buying a new appliance, you can determine the amount of electricity the appliance will use. This information will allow you to compare similar appliances so that you can purchase the most energy efficient appliance. Most new appliances have a tag that looks similar to the one at right:

Model CDF 102
2000 watts 175

This tag identifies the model number and power of the item. Remember that power refers to how much energy it takes to run an appliance and is measured in watts. The power rating on the tag above shows that the item would use 2000 watts. To find the amount of energy used for this appliance, you multiply the power rating by the amount of time that the appliance is used. If the appliance is used for two hours consistently then the math would look like this:

2000W x 2 hours = 4,000Wh or 4kWh

An older appliance in your home might still have the tag. On some appliances such as toasters and televisions, the wattage may be printed on the bottom or back of the device. You may need to do a little detective work and have an adult find the manual to the appliance you are investigating. The manual should have the wattage listed.

How Much Energy Do Household Appliances Use?

Appliance	Power (kW)	Time used (hr./wk or hr./month)	Energy per week or month (kWh)	Cost per kWh	Cost per week or month
Refrigerator					
Microwave					
Clothing iron					
Hair dryer					
Electric range					
Washing machine					
Portable radio					
Television					
Desk lamp					
Blender					
Coffee pot					
Alarm clock					
Stereo system					
Cloths dryer					
Computer					
Video game					
Electric blanket					
Toaster					
Other					

Meter Reader

Purpose

Students will learn how to read a meter to calculate electricity usage.

Materials

practice meter reader sheet
home meter reader sheet
pencil

Procedure

1. Explain how electricity is measured in homes and offices. Tell students that they will be learning how to read a meter to determine how much electricity they use in their homes.
2. Review place value with the students.
3. Distribute the practice meter reader sheets (p. 60) and go over the rules for reading a meter that are located on the practice sheet. Reference the dials and show how they represent place value of a number (ones, hundreds, thousands, and ten-thousands).
4. Students practice reading meters.
5. Go over answers to make sure that the students understand the process.
6. Distribute the home meter reader sheets and ask students to read their meter at the same time each day for four days.
7. Students bring their meter reader sheets to class and calculate how much energy they have used.
8. Discuss and compare the amounts of energy used.
9. Arrange students in groups that represent the different types of homes: apartments, houses, trailers, condos, and so on. Average the energy usage among groups and graph the data. Ask students if they can draw any conclusions from the graph. Why or why not?

Conclusion

1. How did your energy usage compare day to day?_____

_____

_____

_____

2. Explain why usage did or did not differ._____

_____

_____

_____

3. How could you save electricity in your home? List at least three ways._____

_____

_____

_____

_____

Extension

1. Calculate the cost of the amount of energy used per household.
2. Calculate the cost of the amount of energy used by the whole class.
3. Measure and calculate the amount of energy used by the school.

Meter Reader (continued) Practice Sheet

Rules to follow when reading a meter:

- Always read the faces of the meter from left to right.
- The dials of a meter are like watch faces; however, EVERY OTHER DIAL MOVES COUNTERCLOCKWISE.
- If the pointer is between two numbers, always record the number it has just passed. That will be the smaller number, except when passing from 9 to 0; the 0, in that case, represents a 10.

1. _____ _____ _____ _____ _____

2. _____ _____ _____ _____ _____

3. _____ _____ _____ _____ _____

Meter Reader (continued) Home Sheet

Rules to follow when reading a meter:

- Always read the faces of the meter from left to right.
- The dials of a meter are like watch faces. However, EVERY OTHER DIAL MOVES COUNTERCLOCKWISE.
- If the pointer is between two numbers, always record the number it has just passed. That will be the smaller number, except when passing from 9 to 0; the 0, in that case, represents a 10.

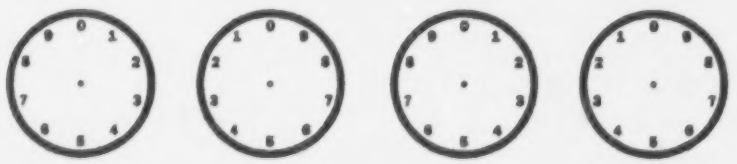
Directions

1. Draw hands as they appear on your meter at home.
2. Record number on the line below dial.

Day 1 Beginning Meter Reading

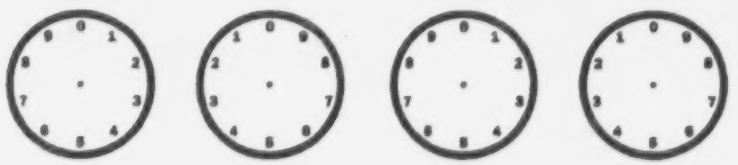
1. _____ _____ _____ _____

Day 2 Meter Reading



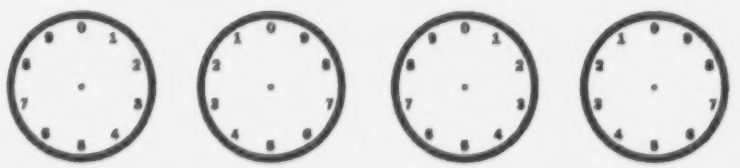
2. _____ _____ _____ _____

Day 3 Meter Reading



3. _____ _____ _____ _____

Day 4 Final Meter Reading



4. _____ _____ _____ _____

1. To calculate how much energy you used daily, take the beginning (day 1) reading and subtract the day 2 reading. To calculate the next day's usage, take the day 2 reading and subtract the day 3 reading and so forth.
2. To calculate total energy usage, take the beginning (day 1) reading and subtract the day 4 meter reading.

Answer Key

Electricity Concept Map (on the web)

1. flowing water
2. batteries
3. watts
4. negative
5. static electricity

Measuring Electricity 101

1. 300 Wh and 0.3 kWh
2. 15,000 Wh and 15 kWh
3. 3,300 Wh and 3.3 kWh
4. 642 Wh and 0.642 kWh
5. 240 Wh and 0.24 kWh
6. 225 Wh and 0.225 kWh

Electrifying Math

1. 550 Wh, 1.15 kWh, $0.12
2. microwave; answers will vary; living room, because it is less wattage; yes, answers will vary.

Meter Reader Practice Sheet

1. 38192
2. 62579
3. 62606
4. 9486
5. 2620
6. 8702